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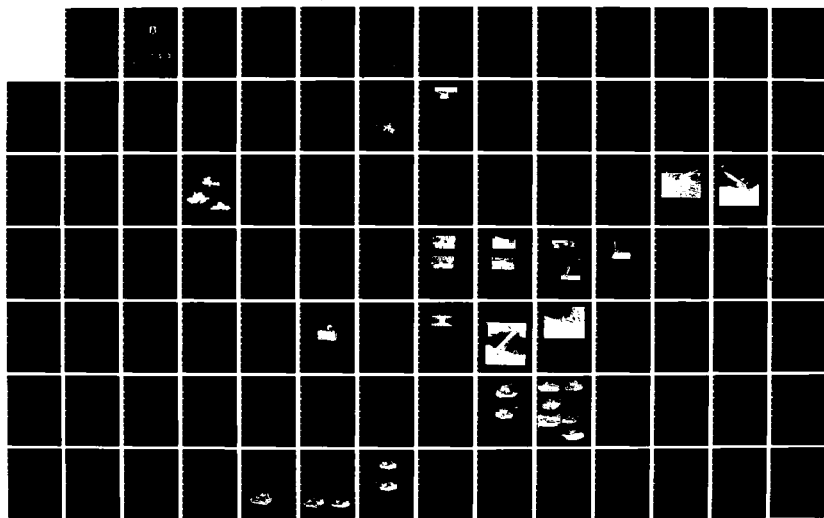
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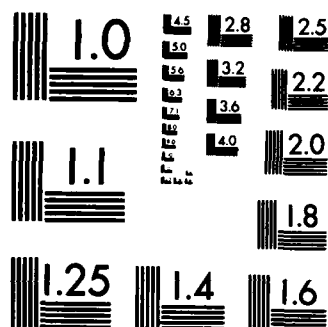
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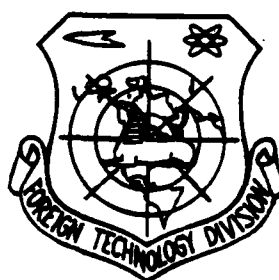
FOREIGN TECHNOLOGY DIVISION



THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY,
30 YEARS OF DEVELOPMENT

by

H. Latos



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FOREWORD

Thirty years have passed since the first regular unit of the People's Armed Forces--the Tadeusz Kosciuszko First Infantry Division--rose up against the Hitlerite invader. The development of the reborn, Polish People's Army dates from this moment. In July 1943 the First Division numbered around 16 thousand soldiers. Later, two Polish armies participated in Operation Berlin, equipped with a considerable amount of military materials and weapons including 3100 mortar units, 500 tank and armored units and 330 airplanes. Such was the origin of the typical armaments and technical equipment of the Polish People's Army. In the last 30 years a systematic modernization of our armed forces has taken place corresponding to the actual concepts of defense, requirements and role of the Polish Army in the powerful defensive system of the Warsaw Pact states.

We owe the manifold development of the armaments and equipment of our armed forces to the fraternal aid of the Soviet Union, which was manifested as organizational, material-technical and cadre support. From the first, the USSR completely equipped our army participating in the war against the Hitlerite Germans, and in the post-war years furnished our defense industry with licenses and broad technical aid in order to accelerate the production of new weaponry and technical military equipment.

The constant strengthening of the defensive force of the Polish People's Army, its equipping with modern technical materials and the heightening of its battle readiness are the results of the deep concern of the Polish United Workers' Party. This is also manifested in deepening the army's ideological homogeneity and consolidating its bonds with the people.

The military power of our army is decided by all the people. The high level of the people's readiness, the tenor and modern style of its activity contribute to the modernity of the Polish People's Army. The Party--always evaluating the seriousness of this problem--points out the path and creates the conditions for the rapid and thorough realization of the scientific-educational potential of the armed forces.

Soviet military specialists have played an essential role in the realization of the army's cadre and didactic potential. A great many of our commanders, specialists, military engineers were schooled in Soviet educational institutions. An expression of Soviet aid is the present defined role of Soviet universities in the formation of our commander and specialist cadres.

Today, really half of the professional military cadre has received a higher education and this indicator is growing rapidly.

Modern scientific and technical progress has been most widely and rapidly utilized in the production of military equipment. Obtained mainly from the Soviet Union, licenses for new technical military equipment contain many progressive structural and technological designs. Also used widely by our industry outside the sphere of the production of weaponry, they hasten the modernization of production processes, raise the level of production automation and intensify the utilization of the means of production in the electromachine, mechanization, aircraft, naval, precision and chemical industries.

The high demands placed upon technical military equipment constitutes a stimulus for the development of contemporary structural and technological designs or new materials. These demands also create

favorable conditions for the development of cadres in industry.

New principles of military strategy seriously influence the working out and the introduction of new weapon models and military materials in the army's equipment. The Polish People's Army in its thirty year history has passed through several periods of technical reconstruction. All weaponry and military materials have undergone thorough modernization in accordance with the general world-wide tendency of the development of military technology. We have had several stages in the development of mechanization, armor, rocketry and electronics for our army, and especially--in the development of automated command systems. This constant process of modernizing the equipment of our army is closely connected with the development of military science and technology. One of the deciding factors in determining the value of a modern army is the level of its adoption of modern weapons and technical-military materials with great technical and military effectiveness, reliability and maneuverability--which correspond to the demands of the contemporary field of war.

This process provides a good illustration of the technological modernization of the armed forces, based on the unusually rapid utilization of technological progress in the army. Results of this progress include the replacement of earlier infantry divisions and regiments with mechanized and armored divisions; the broad introduction of rockets in the military arsenal; the automation of many armament systems supported by electronics; the serious improvement of the system of military communications, of the check beam defense of the country's territory, of the army's anti-aircraft defense; increasing the airforce's effectiveness. Thanks to this we now have a modern army, equipped with highly

effective weapons and military materials, well schooled and with a high moral and political level. We have a series of altogether new military equipment which ensures the meeting of military or administrative requirements, appropriate for contemporary demands and military commands. We have rockets of every class--anti-armor, operational-tactical, sea-based, and also carrier born aircraft. We have effective radio locating stations, radio stations and lines, artillery computers and instruments for the detection of radiation contamination. We have modern, supersonic war planes, ships--and a very complete system of technical military resources necessary to our army.

The manifold development of the scientific and economic potential of the Soviet Union and the other socialist countries allows the equipping of all the armies of the Warsaw Pact with modern, effective weaponry and military materials, but the import of modern supersonic airplanes, rockets and other weapons and military materials is only one of the supply sources of our army. Deliveries of military equipment domestically produced, resting on the results of developmental projects carried out by military and civilian research agencies, as well as on foreign licenses, are also important sources of weapons.

For the production of modern, structurally and technologically complex military equipment, a strong defense industry was finally erected in the country. Over the last thirty years, in cooperation with the Soviet Union, we have created a defense industry which today supplies our armed forces with various weapons and materials. By the fifties, we were producing tanks and ^{war}~~we~~ planes, artillery and rifle pieces, communication and radio locating equipment, engineering ^{and} ~~ad~~ chemical devices, motorized

vehicles and ships. Most of these products were produced thanks to Soviet licenses--the share of domestic construction grew in proportion to the development of our own cadre and technical base. Using Soviet licenses we also produced modern tanks, helicopters, radio stations, new types of artillery and rifles as well as other types of military materials. However, the share of domestically produced equipment or that manufactured by our industry in cooperation with the other countries of the Council for Mutual Economic Aid (CMEA) has significantly grown.

The forms of the multilateral cooperation of the nations belonging to the CMEA, especially the state-members of the Warsaw Pact, have been shaped and developed based on scientific and technological collaboration with the USSR.

The production of armaments and equipment demands the close cooperation of the military with the national economy. This cooperation, bearing both sides benefits, is carried out at all levels of technological progress--in the fields of research, experimental construction and in mass production. Apart from the benefits for the military stemming from this--to some extent based on a reciprocal connection--our armed forces, to a certain degree, also stimulate the huge process of technological advancement within the framework of this cooperation. In the realm of the domestic production of military materials, we are striving to maximally bind the country's defensive needs to the development of the national economy, keeping in mind the maximum usability for the military of newly developed equipment and materials with a universal characteristic or the outpacing characteristic of pure military research in relation to the general advancement of technology in the country. We are widely using the

principles of the standardization and unification of military equipment with that designated for the needs of the national economy. Besides narrow military requirements, the research base of the armed forces is useful for the national economy.

The process of testing our armed forces is a continuous one. The rapid development of modern forms of war, the development of operational ideas and arts cause the incessant perfection of military technology. It becomes more and more complicated--the share of electronic equipment and its automated operation has grown in all fields. This necessitates the continuous upgrading of the quality of technical personnel, the development of research, the perfection of the evaluation of military equipment.

It is impossible to obtain the rapid, dynamic development of military technology without widely utilizing the scientific potential of the entire country. From this comes the high rank of scientific research. Besides the problems closely connected with structural design and the technology of production, it is necessary to develop basic research, especially in those areas of science, such as mathematics, physics, chemistry, medicine and astronomy.

The developmental stages of the armaments and technical equipment of the individual parts of the armed forces, are presented in the individual sections of the book about the thirty year development of the military technology of the Polish People's Army. The principle directions of the initial modifications are drawn and the qualitative transitions in the equipping of the individual parts of the military are noted. The role and contribution of military research agencies in the development of the basic sciences are described and the actual developmental trends in military technology are sketched in accordance with which will be developed the technological equipment of our military, as a well armed and modern army.

This book does not pretend, of course, to be a handbook for military technology--this was not the idea of the publisher, nor is it the intention of the authors of the individual sections. It contains a summary of the more important changes which we have carried out in the last 30 years in the structure and character of the weaponry and technical equipment of the Polish People's Army. This has--in fully keeping pace with the stormy

course of the social and technological revolution and taking an active part in these processes--obtained a high rank in the defensive system of the Warsaw Pact states. This high rank allows a pride in the present achievements and demands the perfecting of present designs.

The development of our armed forces in all aspects, including the technological aspect, was directed especially during the last thirty years of the Polish People's Army in accordance with the resolution of the VI congress of the Polish United Workers' Party (PUWP) which aims at "Strengthening the country's security and preparing the defense of the People's Republic of Poland. The Party will act to strengthen the defensive might of the Polish People's Army, it will intensify its ideological values, it will improve the processes of the education and the schooling of soldiers, and equip them with new fighting materials. It will strengthen the bonds of the army with society, and particularly with the working class, seeing in it the basic source of the military's ideological-moral force.

The Polish People's Army's readiness for defense, its moral and ideological value, patriotism and internationalism, its operational and technical efficiency--these should as before be developed and strengthened, harmoniously connecting the requirements of schooling-defensive efforts with the process of the active construction of socialism in our country.

The Party will strengthen the ideological bonds, the fraternity of the soldiers of the Polish People's Army with the heroic Soviet Army and other allied armies. The Polish soldier by honest service will make it a point of increasing the power of the Warsaw Pact, which constitutes the basis for the peace and security of our continent.

Science and technology are found in an incessant, uncommonly dynamic development. The constant strengthening of our country's security demands the operative application of the effects of the development of science and technology for the increasing of the military power and value of our armed forces. From this are sketched the rich perspectives of further development. Even with this perspective, our knowledge must answer to the requirements of tomorrow.

gen. div. mgr. eng. Zbigniew Nowak

1. THE WEAPONRY AND ROCKET TECHNOLOGY OF LAND ARMIES

1.1 INTRODUCTORY CONSIDERATIONS

Until recently, it was considered that armaments were only weapons and ammunition; it was also defined as classic fire power or the active means to wage war. Not only these classic means of fire power, however, are commonly considered to be armaments. Contemporary armaments of the Polish People's Army, besides rifle and artillery weapons, also include rocket devices, popularly called rocket technology. Within the framework of armament equipment is also included devices intended for the observation and reconnoitering of targets, for directing the firing against the target, for calculating the given firing position for dispositional and executory organs operating armament equipment.

The active means of war--both classic and rocket ones--operating in accordance with internal and external ballistic rules, such as rifles, artillery and rockets, are counted among the elements of armament fire power. On the other hand, observation, reconnoitering, calculation and directional equipment, such as optical-measurement instruments, nighttime viewfinders, radio locating stations, firing directing instruments, artillery computers, geodetic control instruments and others, which enhance the efficiency of the fire power, enter into the framework of armament systems.

The armament of the Polish Army is today quite varied: hand and cap grenades, individual and team rifles, artillery pieces--field cannon, howitzers, mortars, recoilless pieces, anti-armor grenade launchers, tank equipment, ships, coastal defenses, aircraft, and finally, artillery rocket launchers, surface-to-surface rockets (anti-armor guided rockets, tactical and operational-tactical rockets), surface-to-air rockets, designed for hitting targets at low, medium and high ceilings. Finally, we have unguided and guided air-to-air and air-to-surface rockets. Already during the organizational period of 1943-1944, the Polish People's Army was equipped--as in more recent times--with modern armaments, with which it destroyed and disabled various enemy targets, military objects, technical

and transport equipment.

The Polish People's Army, and together with it, its armament, has passed through several stages of intense development in its thirty year history and has undergone a huge organizational and technological transition. A real scientific-technological revolution has taken place. New types of complex equipment have appeared, often with a high level of mechanization or automation and with miniaturized elements. Radio electronic equipment and systems have found more frequent use, for example coding machines. They are connected with control-survey apparatuses, automated command equipment and military supply.

Design and research centers have their own broad role in the development of domestic armaments. While relying upon modern ballistic theories, theories of probability and armor, those of reliability, the physics of solid bodies, quantum electronics and many others, they have made the technology of production more efficient and perfected armament design. The utilization of the achievements of science and technology and the productive possibilities of national industries has lead to the production of many new types of armaments which operate more effectively and fulfill to the highest degree the requirements placed by the users, and to their introduction into the arsenal of the Polish People's Army.

The Polish Army's modern types of weapons are characterized by more and more developed and complex unit designs. This is apparent especially in the complex anti-aircraft weaponry, called anti-aircraft systems, in which the reliability and close collaboration of various elements and devices play an important role. In the mechanisms of the anti-aircraft systems the connections are reversed when necessitated by the conditions for increasing the fire power and mobility of this equipment of the battle field. The efficient and proper utilization of weapons and ammunition in modern armament systems depends upon the linking of armaments with equipment for detecting and reconnecting the target, its identification, the working out of its position, the supply and replenishing of operative and technical-repair elements, that is technical bases which guarantee the armament systems' appropriate technical state. The Polish People's Army has such supplies. This guarantees the proper operation of complex armaments, for which the share of electronic and automated elements (both

classic and rocket weapons) grows from year to year.

1.2 FIRE ARMS

Fire arms, like other types of weapons produced in Poland, in no way differ from those used in the Red Army, which defeated the Hitlerean invaders. From the sniper's blade, the pistol and carbine all the way to the high caliber machine gun and anti-armor weapons, weapons, mass produced by the powerful armaments industry in the USSS in wartime, were tested in the war. These weapons, in numbers necessary for waging war and compensating for losses caused by military actions, were handed over to Polish soldiers, who carried them at Lenino on the Laba and returned with them to their country in full glory.

Divisions of the Polish People's Army were armed, among others, with the following types of fire arms: a 7.62 mm rifle (design years 1891/30), a 7.62 mm carbine (1944 and 1938), a 7.62 mm sniper's rifle (1891/30) with a PU telescopic range finder, the Tokar^{ey} 7.62 mm pistol (1933), the PPS^h 7.62 mm automatic pistol (1941), the PPS 7.62 mm automatic pistol (1943), the Simon and Tokar^{ey} 7.62 mm semi-automatic rifle, the so-called SWT and AWS, the DP 7.62 mm manual machine gun (1928), the DT and DTM 7.62 mm tank machine gun, the Maxim 7.62 mm heavy machine gun (1910), the DS^h 12.7 mm large caliber machine gun and the PTRD and PTRS 14.5 mm anti-armor guns.

Two trends can be distinguished in the development and production of fire arms in Poland after the Second World War, whose practical realization developed unequally--depending upon the growth of the production potential and the formation of domestic cadres of specialists. On one hand, production rested on licenses, and on the other, on our own designs.

The first, initial work was begun right after the war. This constituted the preparatory stage, relying upon joint stock-taking for

defects and the establishment of factual technical condition of individual weapons. This was accompanied by on-going repairs thanks to the use of stocks of replacement parts from the war period and those derived from worn out, and defective equipment.

To begin weapons production in a country devastated by war was unbelievably difficult. The factories of the weapons industry, besides that used for the production of equipment during the occupation, were destroyed by the occupier, and machinery was removed deep into Germany. The creation of an armaments industry was marked from the completion of machinery and equipment frequently recovered under the rubble of factories, and from the formation of cadres of specialists, diminished by the occupation's terror. Despite huge obstacles, already from 1946 the production of fire arms' replacement parts had been begun in Poland.

The first fire arm models produced in the country after the Second World War were the TT 7.62 mm pistol (1933), a 26 mm and 7.62 mm signal pistol (1944), which were produced respectively in 1947, 1948 and 1950 on the basis of technical documentation worked out by Polish armament specialists, who analyzed the earlier weapon models and license documentation. Experience obtained in the course of production allowed them to proceed in the already planned onset of domestic weapons production.

The broad application of the rich experience of the Soviet armament industry was begun in 1950. This was expressed in the accession to design and technological documentation and in the aid of Soviet specialists, who as advisors were sent to Poland when it was necessary to master the production of the fire arm models which made up the armaments of the Polish Army at that time.

The necessity of hurrying the armament industry's development was a result of the tension then existing in international relations and the need for the rapid creation of a corresponding production potential capable of meeting the supply needs of the Polish Army. This task was practically realized by the end of 1955 at the cost of a huge national effort and the manifold aid of the USSR.

During this period the newest weapon models necessary for the Polish Army were produced. At the same time, a corresponding method was applied and the needed group of specialists formed, educated by the Military

Technical Academy (WAT) and civilian universities, capable of penetrating to the heart of the manifold technical problems of the mass production of fire arms. And so, in 1951, the production of a 7.62 mm automatic pistol (1943), was begun. 1952 saw the production of a 7.62 mm automatic pistol (1941), 1953--the DP 7.62 7.62 mm manual machine gun (1928), the DTM 7.62 mm tank rifle and a 7.62 mm heavy machine gun (1943). 1954 saw the production of the DPM 7.62 mm manual machine gun. The production of the corresponding ammunition began at the same time.

Much of the above mentioned equipment was produced in the Soviet Union during the inter-war period and the Second World War. The technical and application value of these weapons met the contemporary demand.

The first postwar years brought fundamental changes with regard to the application of earlier weapons. These changes were caused by wartime experiences, technical analyses and the tactics of war, especially in the face of the use of nuclear weapons at the war's end. The role of machine guns especially diminished, mainly with regard to its limited firing distance of 200 m. Moreover, the desire to simplify supply and repair caused all armies to decrease the number of weapon types and to introduce as far as possible the unification of parts.

The repercussions of these trends were also felt in the Polish Army. The years 1955 and 1956 marked a turning point, because the verification of the weapons in question had been performed in order to adapt them to the developmental tendencies of the world's leading armies, above the that of the Soviet Union.

Starting from 1957, the production of the AK 7.62 mm rifle and the RPD 7.62 mm manual machine gun was initiated--as weapons adapted to ammunition designed in 1943 with increased force in comparison with pistol ammunition. These weapons based on medium ammunition from 1943, as the individual rifleman's automatic weapon, allow firing of up to 600 m, and hence, within the range of the infantry's practical, tactical operation, with a force no less than that of an automatic pistol.

On the basis of technical documentation obtained from the USSR, the national industry in the period from 1956 to 1958 began the production of the AK 7.62 mm rifle with wooden and metal stocks, and the D 7.62 mm manual machine gun together with a new type of ammunition, adapting these weapons--until the end of 1961--to the needs of nighttime warfare, by using nighttime sights. Simultaneously, in 1958, the production of a 7.62 mm tank machine gun was begun, which was designed as a carrier borne weapon for the more recent version of tanks and armored transport. Also, in 1960 was begun the production of the ZU-2 14.5 mm large caliber machine gun, designated for the defense of the army against the low altitude attacks of airplanes and helicopters. The alteration process was finished in 1968 with the production of the Kalasznikow or PKS 7.62 mm universal automatic rifle.

Starting in 1965, parallel with introduction of new rifles in the army, the newest real achievement of design ideas in this field, the new version of the Kalasznikow rifle, was introduced, which was characterized by less weight and fewer man hours needed for individual production operations. In 1966, the production of the AKM 7.62 mm rifle was initiated, and in 1972--the AKMS 7.62 mm rifle.

For the arming of tanks the production of the PKT 7.62 mm tank machine gun was begun. ¹⁹⁶⁸ The ~~Vladimirov~~^V-KPWT 14.5 mm large caliber machine gun was put into production in 1970 as the armament of the SKOT-2A armored transport.

The 5.6 mm rifle (1948) opened the production of domestic designs. It was designed as a training weapon for soldiers, who were armed with a 7.62 mm rifle (1944). The needs of the army also led in the first period to the modernization of the 7.62 mm automatic pistol (1943) with the addition of a permanent wood butt, as well as the reconstruction of the barrel extension. This weapon's production under the name, 7.62 mm automatic pistol (1943/52) was begun in 1952 to meet the need of infantry sub-units for light arms which only required simple production technology comparable to that of the 7.62 mm automatic pistol (1941).

In 1958, a competition was scheduled for a 9 mm army pistol. 4 institutions designed such a weapon and presented the prototypes for study to the evaluation commission in 1961. As a result of the thorough study of the prototypes, the 9 mm pistol designed by a team of officers from the Military Institute for Weapon Technology was chosen for further consideration. After the perfection of this pistol's design--chiefly from the point of view of operating reliability and the durability of its parts--this pistol, called the 9 mm pistol (1964), was introduced as a weapon of the army in 1964.



The AKM 7.62 mm rifle with nighttime sight



Figure. Large caliber machine gun
EKM-2 cal. 14.5 mm.

This pistol is characterized, in comparison with the TT 7.62 mm pistol (1933), by considerably smaller dimensions and weight, while retaining the earlier destructive force at distances of up to 50 m. Moreover, the use of a double action trigger-percussion mechanism and cartridge indicator in the barrel increased the efficiency of the pistol's usage in battle and ensured its rapid one hand use. Its given advantages made it a weapon which met the contemporary requirements placed on these types of pistols.

The next design--the 9 mm automatic pistol (1963)--arose as the practical realization of world-wide developmental tendencies concerning this type of weapon. It was intended for soldiers of special sub-units as well as those who carried out other missions in wartime and used rifles in critical battle situations: surprise or destructive attacks upon basic targets such as tanks, aircraft, etc. This weapon was used everywhere the 7.62 mm AK rifle was-- with regard to its dimensions and weight. It could hinder the performance of basic tasks, but the pistol could not guarantee an effective defense during an enemy's surprise attack.

This weapon--adapted to the Makarov^V~~wa~~ type 9 mm cartridge--is characterized by good accuracy during series firing at a distance of up to 150 m, small dimensions and an insignificant weight, ease of one-handed service and operational reliability. This pistol can also be easily adapted to Parabellum type 9 mm cartridges. The pistol's production was begun in 1964 and was included as a weapon of the Polish Army in 1965 under the name of the 9 mm pistol (1963).

We must also include the 7.62 mm rifle-howitzer (1960) among domestic designs. It is an adaptation of the AK^{7.62}rifle with a wood butt; it

serves as a launcher of anti-armor and fragmentation grenades. The adaptation was carried out in 1960. It did not diminish the useful properties of the rifle as the weapon of individual riflemen.

Besides the design efforts of the above mentioned weapon examples, other experimental designs were studied. Among others was designed a version of the AK 7.62 mm rifle, as a sniper's weapon, which modernized the circular base, the 7.62 mm heavy machine gun (1943), etc.

The Polish Army, operating within the framework of the armies of the Warsaw Pact states, can always make use of the experiments of the specialists of friendly armies and the deliveries of other types of rifles, whose need does not justify the necessity of raising their production to the industrial scale in the country. An example of this can be the Simonowa 7.62 mm automatic carbine.

| 13) Lp. | 14) Wyszczególnienie parametrów | 23) Wzrost i typy broni strzeleckiej | | | | | | | | | |
|---------|---|--------------------------------------|----------------|----------------|--|---|---------------------------|-----------------------|-------------|-------------|--|
| | | 15) P wz. 33 TT | 16) PPS wz. 41 | 17) PPS wz. 43 | 18) kb wz. 91 30 i kb wybor. wz. 91 30 z celow. PU | 19) kb wz. 38 i kb wz. 44 (z bagnietem) | 20) km wz. 28 (DP, i DPM) | 21) ckm wz. 910 Alama | PTKD wz. 41 | PTKS wz. 41 | |
| 1 | Kaliber broni (mm) | 7,62 | 7,62 | 7,62 | 7,62 | 7,62 | 7,62 | 7,62 | 14,5 | 14,5 | |
| 2 | Ciężar broni bez naboju (kg) | 0,854 | 3,800 | 3,300 | 4,0 | 3,9 | 10 | 20 | 17,3 | 21,0 | |
| 3 | Ciężar broni z załadowanym magazynkiem (kg) | 0,940 | 5,400 | 3,650 | 4,1 | 4,0 | 11,2 | 25 | 17,5 | 22,0 | |
| 4 | Długość broni (mm) | 190 | 842 | 616 831 | 1230 | 1020 ÷ 1330 | 1266 | — | 2000 | 2200 | |
| 5 | Szybkostrzelność (strzałów/min) | 8 | 30 ÷ 100 | 30 ÷ 100 | 10 | 10 | 600 80 | 480 ÷ 600 300 | 10 | 10 | |
| 6 | Prędkość początkowa pocisku (m/s) | 420 | 500 | 500 | 865 | 820 | 840 | 800 ÷ 865 | 1012 | 1012 | |
| 7 | Odległość ognia skutecznego (odległość celowania) (m) | 50 | 200 | 200 | 1000 | 1000 | 1000 | 1000 | — | — | |
| 8 | Pojemność magazynka (taśmy) (szt. naboju) | 8 | 35/71 | 35 | 5 | 5 | 47 | 250 | 1 | 4 | |
| 9 | Długość lufy (mm) | 116 | 243 | 223 | 730 | 517 | 605 | — | — | — | |
| 10 | Ciężar naboju (G) | 11 | 11 | 11 | 21,8 | 21,8 | 21,8 | 21,8 ÷ 23,8 | 200 | 200 | |
| 11 | Ciężar pocisku (G) | 5,5 | 5,52 | 5,52 | 9,6 | 9,6 | 9,6 | 9,6 ÷ 11,8 | 63,5 | 63,5 | |
| 12 | Zasilanie | mag. | mag. | mag. | mag. | mag. | mag. | taśma | — | mag. | |

Table 1.1 A comparison of the specifications of the basic parameters (tactical-technical data) of the firearms of the Polish People's Army between 1943 and 1945.

1. weapon caliber, 2. weapon's weight without cartridge, 3. weapon's weight with loaded magazine, 4. weapon's length, 5. firing speed (shots/min), 6. initial projectile speed, 7. accurate firing distance (aiming distance), 8. magazine capacity (belt) (cartridge), 9. barrel length, 10. cartridge weight, 11. projectile's weight, 12. feed, 13. number, 14. parameters' specification, 15. TT pistol (33), 16. PPS automatic pistol (41), 17. PPS automatic pistol (43), 18. rifle (91/30) and sniper rifle (91/30) with PU sights, 19. carbine (38) and (44) (with bayonet), 20. hand machine gun (28), 21. Maxim heavy machine gun (1910), 22. belt, 23. models and types of firearms.

| 13) Lp. | 14) Wymagania parametrów | 15) Wzory broni strzeleckiej 18) | | | | | | | | | |
|---------|--|----------------------------------|---------------|----------------------------|------------------|----------|--------------------------|---------------|------------------------|---------------------------------|----------------|
| | | na naboje pistoletowe | | na naboje pośrednie wz. 43 | | | na naboje karabinowe 17) | | | | |
| | | 19) P wz. 64 P-44 | 20) pm wz. 63 | 21) km AK | 22) km AKM, AKMS | 23) km D | 24) kb wyb. SWD | 25) km PK PKS | 26) km wz. 43 SG SGM/T | 27) wkm wz. 38/46 i wz. 38 DSzK | 28) wkm PKMZ-2 |
| 1 | Kaliber broni (mm) | 9 | 9 | 7,62 | 7,62 | 7,62 | 7,62 | 7,62 | 7,62 | 12,7 | 14,5 |
| 2 | Ciętar broni — bez amunicji (kg) | 0,620 | 1,620 | 3,8 | 3,5 | 7,4 | 4,3 | 9 | 14,8 | 34 | 50,2 |
| 3 | Ciętar broni — z amunicją (kg) | 0,680 | 2,000 | 4,3 | 4,0 | 9,0 | 4,8 | 11,18 | 20,0 | 40,5 | 80,2 |
| 4 | Długość broni (mm) | 159 | 332 | 870 | 870 | 1040 | 1225 | 1173 | 1128 | 1591 | 2000 |
| 5 | Szybkostrzelność (strzał/min) | 30 | 40 ÷ 100 | 600 | 600 | 650 | 30 | 650 | 600 ÷ 700 | 560 ÷ 600 | 1100 |
| 6 | Prędkość początkowa pocisku (m/s) | 310 | 330 | 90 ÷ 100 | 90 ÷ 100 | 150 | 250 | 350 | 80 | 300 | |
| 7 | Odległość ognia skutecznego (m) | 50 | 350 | 800 | 1000 | 800 | 1200 ÷ 1300 | 1000 | 1000 | 1500 | 2000 |
| 8 | Pojemność magazynka (taśmy) (szt. nabci) | 6 | 15/23 | 30 | 30 | 100 | 10 | 100 ÷ 200 | 250 | 50 | 150 |
| 9 | Długość lufy (mm) | 67,5 | 130 | 415 | 415 | 520 | 620 | 658 | 828 | — | — |
| 10 | Ciętar naboju (G) | 10 | 10 | 16,2 | 16,2 | 16,2 | 21,8 | 21,8 | 23,8 | 125 ÷ 137 | 200 |
| 11 | Ciętar pocisku (G) | 6,1 | 6,1 | 7,9 | 7,9 | 7,9 | 9,6 | 9,6 | 11,8 | 43 ÷ 49 | 60 ÷ 69 |
| 12 | Zasilanie | mag. | mag. | mag. | mag. | taśma | mag. | taśma | taśma | taśma | taśma |

Table 1.2 A comparison of the specifications of the basic parameters of firearms in the arsenal of the Polish People's Army between 1970 and 1973

1. weapon's caliber, 2. weapon's weight without ammunition, 3. weapon's weight with ammunition, 4. length of the weapon, 5. firing speed, 6. initial projectile's speed, 7. accurate firing distance, 8. magazine capacity (belt) (cartridge), 9. barrel length, 10. cartridge weight, 11. projectile's weight, 12. feed, 13. number, 14. parameters' specification, 15. in pistol cartridges, 16. in intermediate cartridges (43), 17. in rifle cartridges, 18. firearm models, 19. P-64 pistol (64), 20. automatic pistol (63), 21. AK carbine, 22. AKM, AKMS carbine, 23. D hand machine gun, 24. SWD sniper rifle, 25. PK PKS machine gun, 26. SG SGM/T heavy machine gun (43), 27. DSzK large caliber machine gun (38/46) (38), 28. PKMZ-2 large caliber machine gun

1.3. ARTILLERY EQUIPMENT

THE ARTILLERY OF THE POLISH PEOPLE'S ARMY BETWEEN 1943 AND 1945

Artillery, as one of the main and most effective means of defense and fire power support of an army in all types of war, is an old but constantly efficient fighting tool (against stationary as well as mobile targets; against shielded, armored and non-shielded--exposed targets) using direct or indirect fire--from concealed firing positions.

The Polish People's Army during its formation between 1943 and 1945 and directly after World War II was equipped with the following artillery equipment:

1. 76 mm caliber regimental and divisional field guns (artillery), predominately horse-drawn. The guns' range amounted to between 6 and 11 km. Because of its limited weight (around 1.3 tons), they constituted the concurrent artillery of the detachments and tactical units.
2. 122 and 152 mm howitzers, weighing 2.5 and 3.6 tons, towed by tractor and used as a rule for opposing enemy troops and artillery found defending them (for example, in the reverse slopes of hillocks. The angle of the barrel's rise (around 70%) calls for firing with a steep trajectory. The initial projectile's speed was less than that of cannons and amounted to around 500 m/s.
3. 122 mm caliber field cannon and 152 mm caliber howitzer-cannons, which are included within the framework of corps and army artillery. The range of these pieces was around 20 km, and their weight, 7 tons. They were transported by tracked vehicles.
4. 50, 82 and 120 mm caliber mortars--carried by troops or drawn by horse (the 120 mm mortar) and weighing 20, 56 and 250 kg. Loaded from

25

the side of the muzzle, they fired shells at a steep angle stabilized by the shaft. These mortars had resistance plating, but not locks and bottom mounts.

5. 45 and 57 mm caliber anti-armor cannon towed by horse and weighing .8 and 1.2 tons, firing individual (solid) anti-armor shells and sub-caliber ones with a core of sintered carbide. These guns were characterized by their exceptional armor penetration capabilities (up to 185 mm from a firing distance of 100 m--at a projectile impact point of around 90° to the armor).

6. 76 and 152 mm caliber self-propelled guns, mounted upon a tank. These guns were characterized by the lack of a rotating turret, but their armor and maneuverability enhanced the possibilities of coordinated action with the infantry.

7. 37 mm caliber automatic anti-aircraft cannon (weighing 2.1 tons) with a theoretical firing speed of around 180 rounds per minute with range finders, designed for hitting targets at a ceiling of 3-5 km, firing shells with percussion fuses, as well as 85 mm caliber semi-automatic anti-aircraft cannon weighing 4.9 tons, firing fragmentation shells with timed fuses, reaching a ceiling of 6-9 km (furnished to artillery computers). These cannon were transported by tractor.

8. 76 and 85 mm caliber tank cannon mounted on the T-34 tank's rotating turret.

CHANGES IN THE ARTILLERY OF THE POLISH PEOPLE'S ARMY

In the 30 year existence of the Polish People's Army important changes have taken place in its artillery weapons. Horse transport has been mechanized. Typically, cannons are moved by wheeled or tracked vehicles, mostly of domestic production. These vehicles also transport the guns' personnel, ammunition and optical-measuring

equipment or other devices constituting the unit's equipment. Other changes include the significant improvement in the manner of gathering data for the gun's precise aiming, both by shortening the time necessary for gathering the ballistic and meteorological data, as well as the more precise calculation of corrections. This has contributed to the introduction of new range finders, nighttime sights, firing direction instruments, instruments for the precise determination of coordinated firing positions and observation points as well as correction computers. 26

The 76 mm regimental and divisional cannons were withdrawn. Their place was taken by cannon capable of varied uses. These are relatively light, mobile and simple--thanks to the use of accumulative, rotationless shells--very effective as anti-armor cannons capable of destroying modern armored targets and for hitting unarmored targets with fragmentation shells. They are characterized by a greater accuracy and a firing speed which reaches 20 rounds per minute, as well as by a relatively light weight (1.7 tons).

The 45 and 57 mm anti-armor cannon were also removed from the artillery sub-division's arsenal. These cannon were replaced by heavy anti-armor howitzers with recoilless rocket action. The howitzers' light weight, their greater firing distance and their effective firing range make them a fearful weapon, which can penetrate with their accumulative shells the armor of every contemporary tank. The equipping of these howitzers with nighttime sights increases their usefulness, that is, accurate firing also under nighttime conditions.

The 50 mm mortar was withdrawn because of its limited range. The 27

tasks of these mortars are performed by cap grenades fired by rifles. The 160 mm mortar, introduced in the first years of the 1950's, was also removed. Paratrooper sub-divisions were armed with light self-propelled cannon mounted on tracked vehicles (adapted also to transport aircraft) as well as recoilless guns with fragmentation-demolition and anti-armor ammunition. The 82 mm mortar together with ammunition has also been adapted to the needs of paratroopers.

Subsequent changes touched military transport. Some transports were equipped with smooth bore cannon which fire accumulative anti-armor shells with rocket propulsion. 100 mm guns, domestically produced, were used in tanks, stabilized both vertically and horizontally, allowing the firing of accumulative fragmentation-demolition or common anti-armor shells with a great initial speed. These tank cannon are also equipped with ejector devices (removing the explosives' gases from the barrel after firing) and a nighttime sight allowing accurate firing at night.

The greatest and farthest reaching changes in the mentioned thirty year period transpired in the field of anti-aircraft artillery. The 57 mm automatic anti-aircraft cannon was introduced, mounted individually on wheeled vehicles and in tandem on tracked vehicles. They serve for hitting airborne targets. Anti-aircraft artillery mounted on wheeled vehicles work with radio-locating computer teams, from which they obtain the barrel's azimuth and rise angle, corresponding to the coordinate point of the attack, that is, the shell's impact with the target.

The 100 mm semi-automatic anti-aircraft cannon equipped with computer and radar station also falls within the framework of the anti-aircraft

artillery arsenal. These cannons fire fragmentation-demolition shells with timed fuses at airborne targets. The computer, operating in these units, is a mathematical machine. It receives the azimuth, the target's height and its distance from the radar station, computes the coordinate point of the shell's impact with the target, sets the cannon's azimuth and rise angles, and sets the fuse's explosion time. These cannons were equipped with hydraulic propulsion with great angular aiming speeds.

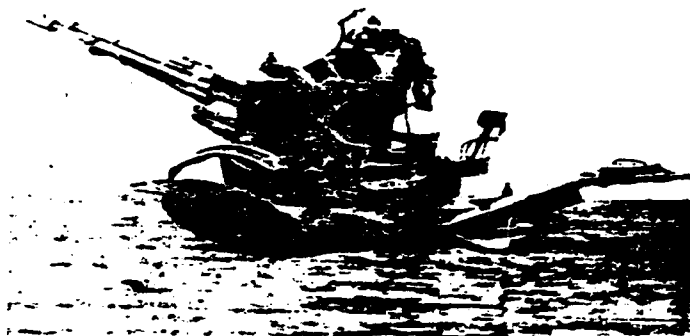
23 mm automatic, double barreled cannon on wheeled chasses and four barreled self-propelled 23 mm cannon equipped with computers and radar stations are also in the anti-aircraft arsenal. The theoretical firing speed of these guns is 1000 rounds per minute.

THE DEVELOPMENT OF POLISH SCIENTIFIC-TECHNICAL DESIGN IN THE FIELD OF ARTILLERY

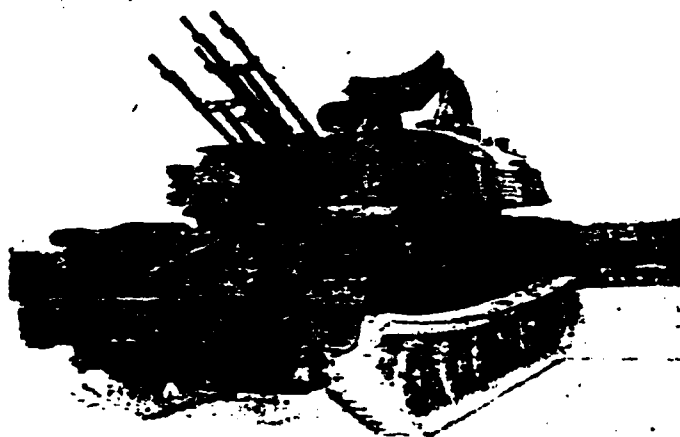
The design activity of the institutes and attached bureaus led to the development and practical use of a series of modernizations in artillery equipment. New types of ammunition were developed thanks to which the qualities of tactical-technical equipment were improved, adapting it to the needs and requirements of contemporary warfare, that is, the rate of the army's advance, command efficiency, the speed of decision making, etc. And so, among other things, field unit transports were adapted to modern methods of transportation, introducing braking and signalling systems; mortars were adapted to firing from armored transports and angular limiters were introduced, used for instructional firing. An entire series of new types of ammunition was developed and introduced, as well as flash-smoke cartridges, training shells and fuses, used on limited practice

ranges, not harming them. They also allow firing at enclosed training areas (dummy shells, etc.).

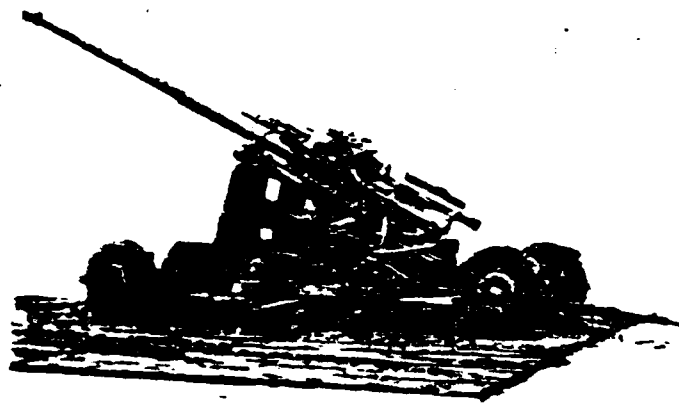
In the national design offices many training devices were devised (for ex. for the science of loading equipment with training ammunition as well as facilitating the activity of artillery systems without setting into motion current producing groups). Artillery equipment and ammunition are adapted for crossing water obstacles by day.



The 23 mm caliber anti-aircraft cannon



The ZSU-23-4 anti-aircraft cannon



The 100 mm caliber anti-aircraft cannon

| Lp. | Wyszczególnienie parametrów | Wzrosty sprzętu | | | | | | | | | | |
|-----|---|-----------------------------|------------------------|-------------------------------------|------------------------------------|-----------------------------|------------------------------|-----------------------------|-----------------------------|------------|--------------|---------------|
| | | Art. panc. | | Art. polowa | | | | | | Mortiziera | | |
| | | 45 mm armata wz. 37 i 42 | 57 mm armata wz. 43 | 76 mm armata dywizyjna wz. 42 | 76 mm armata polowa wz. 1902 | 122 mm ha- bitica wz. 38 | 122 mm arma- ta wz. 31/37 | 152 mm ha- bitica wz. 37 | 152 mm ha- bitica wz. 43 | 50 mm | 82 mm wz. 37 | 120 mm wz. 43 |
| 1 | Kaliber (mm.) | 45 | 57 | 76,2 | 76,2 | 122 | 122 | 152 | 152 | 50 | 82 | 120 |
| 2 | Ciężar (kg) | 560 625 | 1250 | 1150 | 1230 | 2500 | 8050 | 8070 | 3600 | 10 | 50 | 555 |
| 3 | Szybkość początkowa pocisku (m/s) | 760 870 | 706 | 680 | 588 | 515 | 800 | 655 | 508 | — | 211 | 272 |
| 4 | Cisnienie maks. w lufie (kg/cm ²) | 2900 | 3100 | 2920 | 2200 | 2350 | 2750 | 2350 | 2250 | — | 430 | 1030 |
| 5 | Ciężar naboju (kg) | 2,5 | 6,6 | 8,8 | — | 27 | 40,6 | 60 | 49 | 1,1 | 3,15 | 16,4 |
| 6 | Ciężar pocisku (granatu) (kg) | 1,43 | 3,14 | 6,2 | 6,5 | 21,76 | 25,0 | 43,5 | 40 | 1,0 | 3,1 | 15,9 |
| 7 | Odległość strzału bezwzgl. (m) | 950 | 1100 | 820 | — | 600 | 975 | 800 | 580 | — | — | — |
| 8 | Długość armaty (mm) | 4020 4885 | 6800 | 6095 | — | 5900 | 8900 | 8175 | — | — | — | — |
| 9 | Kąty ostrzału pionowego (stopnie) | 33 | 30 | 42 | 17,0 | 66 | 67 | 67 | 66 | 45÷80 | 45÷85 | 45÷80 |
| 10 | Kąty ostrzału poziomego (stopnie) | 60 | 54 | 54 | 5,4 | 49 | 58 | 58 | 35 | 6 | 6 | 8 |
| 11 | Szybkostrzelność (strzał/min) | 20÷25 | 15 | 25 | 10 | 6 | 4 | 3 | 4 | 40 | 30 | 15 |
| 12 | Szybkość holowania (km/godz) | 30÷50 | 50 | 50 | 20 | 50 | 20 | 20 | 40 | — | — | 60 |

Table 1.3 The specifications of the basic parameters for the artillery of the Polish People's Army between 1943 and 1945

1. caliber, 2. weight, 3. initial projectile speed, 4. maximum pressure in the barrel, 5. cartridge weight, 6. projectile (shell) weight, 7. firing distance, 8. cannon length, 9. vertical firing angle (degrees), 10. horizontal firing angle (degrees), 11. firing speed (rounds/min), 12. transportation speed (km/hour), 13. number, 14. specification of parameters, 15. equipment type, 16. anti-armor artillery, 17. field artillery, 18. mortars, 19. 45 mm cannon (37 and 42), 20. 57 mm cannon (43), 21. 76 mm divisional cannon (42), 22. 76 mm field cannon (1902), 23. 122 mm howitzer (38), 24. 122 mm cannon (31/37), 25. 152 mm howitzer-cannon (37), 26. 152 mm howitzer (43), 27. 82 mm (37), 28. 120 mm howitzer (43).

As the result of introduced and, consequently, implemented innovations, the basic developmental direction of artillery equipment in the Polish People's Army between 1943 and 1973 was made up of the following:

--first--improving the efficiency of target destruction by perfecting the equipment, both by improving its characteristics and by introducing new types of equipment and ammunition;

--second--adapting artillery equipment to a mobile war, and therefore mounting the equipment on wheeled or tracked vehicles, which became particularly apparent with anti-aircraft artillery as well as with the concomitant artillery of armored, paratroop and coast guard subunits;

--third--automating targeting with the calculation of the initial data for firing.

Resources for the development of artillery were allocated for the uninterrupted modernization of this equipment, scientific study, experimental-design work and the production of new types of equipment. All of these undertakings facilitated the systematic repair of the technical state of the artillery and adapted it to the new demands of warfare. Meeting these demands was all the more complicated by the large growth in design and production costs. The decisions made in this respect were often compromised between the technical and economic possibilities of industry, and increased demands in relation to the battle properties of new equipment. For example, if the cost of the first generation of anti-aircraft artillery is taken as 100 (1945-50), the cost of the second generation amounted to 300 (1955-60), and of the third generation (1965-70) of units of this equipment, 1000-2000. It must be explained here that the first generation included equipment manually targeted, the second--equipment targeted semiautomatically and controlled by aid of radar stations and computers. The third, however, is equipped

with automated multibarrel units with radar-computers, mounted on self propelled tracked vehicles.

The modernization of artillery has led to the expansion of technical-repair subsidiaries, capable of control-measurement and production-repair activity, guaranteeing the operation of ever more complex equipment.

THE DIRECTIONS OF THE DEVELOPMENT OF ARTILLERY

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The decrease in the dimensions and weight of the artillery units was a result of perfecting the design of this equipment in the Polish People's Army. This is especially evident in antiarmor artillery and that used in paratroop and coast guard units. Taking into consideration the principles of organization and the level of use, the greatest benefit was yielded in the improvement of supply as well as the adaptation of the equipment to air transport and air drop.

The next characteristic of the artillery equipment newly introduced into the Polish People's Army was an improvement in the firing precision. This was achieved thanks to the use of equipment which targeted and calculated the initial data for needed firing. All the introduced modernizations required the excellent preparation of personnel and good deal of time in inspecting the equipment. The artillery equipment's most expensive elements were the barrels, the recoil mechanisms as well as the hydraulic and electrical systems of the targeting mechanisms, and its electrical elements. The usage life and reliability, that is, the efficiency of the operation of these elements, have an important significance for all the armaments found

within the framework of artillery units.

The increase in the artillery's tactical mobility was accomplished by the partial changeover of towed artillery to self-propelled equipment, and by lessening the weight of towed cannon. Some self-propelled cannon were mounted on amphibious vehicles. This allowed the surmounting of water obstacles and the crew's defense from machine gun fire and fragmentation shells. 32

The intensification of the Polish Army's artillery fire has increased thanks to the introduction of rapid firing field rocket launchers, mounted both on light tracked vehicles and on self propelled areal vehicles.

A very important factor influencing the improvement of the effectiveness of artillery fire was the introduction of instruments for observing the battle field, for discovering and identifying the targets such as range finders, radar stations, nighttime sights, etc., as well as computers, correctors and other devices which serve to correct the fire and determine the initial firing. Specialized artillery computers made up of electronic components serve for the precise calculation of the sight's adjustment.

Besides anti-aircraft artillery, anti-armor artillery occupies an important place in the system of anti-armor defense. Tactical units and detachments have been equipped with anti-armor devices to such an extent and in such a proportion in order to achieve the greatest level of anti-armor defense at the lowest possible financial cost. New designs for accumulative shells for anti-armor guns with so-called 33

rotationless rifled barrels, which are characterized by greater armor piercing ability, have contributed to this. So have shells with a greater range and accuracy, as well as the development of new artillery equipment, characterized by rapid fire and the rapid change of firing positions.

Anti-armor artillery devices, included within the system of anti-armor defense of the Polish People's Army, are quite varied with regard to their range and efficiency. Included in this system are smooth barrel cannon, recoilless guns, rocket-recoilless howitzers and rifled anti-armor cannon with classic anti-armor shells. The firing components of the anti-armor artillery of the Polish People's Army--including artillery ammunition--have also undergone great changes. For example, the army has withdrawn some types of recoilless guns, introducing in their place anti-armor howitzers with a greater effective range and firing shells with improved armor piercing abilities. Cannon and howitzers have been equipped with nighttime sights, allowing firing in the night and in conditions of limited visibility. Passive nighttime sights have also been introduced, using the stars and moon as well as the nighttime sky as their light source.

The artillery of the Polish People's Army has undergone constant modernization. Changes have resulted from the moral and technical aging of some types of equipment and from the appearance of targets, characterized by new parameters (for ex. airborne targets). These changes have also reflected the race between ammunition and armor. This race has been won in the extreme by the accumulative shell.

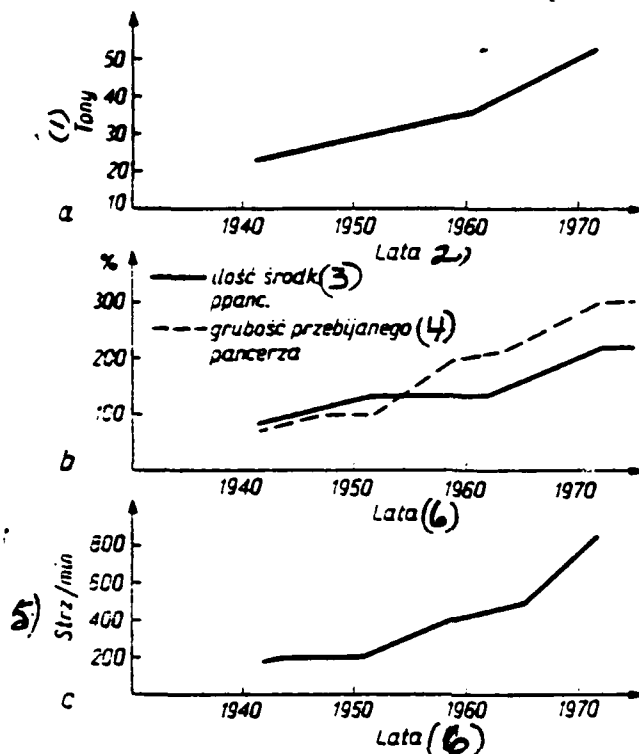
The aspiration of the designer and technician to use the best features

of the material as well as to achieve the tactical-technical optimum (for ex. increasing the projectile's initial velocity thanks to the use of powder with a better caloricity) has influenced in a basic way the use life of basic elements of artillery equipment, such as the barrel, muzzle, the recoil mechanisms, the upper mount, etc. Analysis of the development of the artillery in recent years has shown that the period of its moral and technical obsolescence is from 10 to 30 years and that the prolongation of its exploitation period is valid for that equipment which does not succumb to rapid moral and technical obsolescence. 34

The time, necessary for discovering the target until its destruction, plays the deciding role in artillery activity and bears upon the design of its equipment. Artillery constantly seeks to shorten this time. To do this equipment has been developed for the rapid, automatic discovery of the target, the determination of its coordinates, the working out of the guns' adjustments and the transmission of that data to the executory organs. This has required the introduction of hydraulic or electrical systems, the use of electromechanical instruments, electronic calculating elements and even computers. Artillery equipment has become complicated, both in its production and use.

Powerful electric engines, propelling individual gun units, nighttime sights, amplifiers, voltage rectifiers, transformers and other elements require a continual supply of energy. Therefore, besides electrolytic cells and batteries (for ex. silver zinc ones), electric current producing aggregates, supplying collectors with the energy of an electrical current, were introduced into artillery units. Artillery equipment constantly steps beyond the field of the weapon itself. It presently encompasses an entire series of devices 35

needed for discovering the target, aiming the shell at the target and calculating the data which ensures the target's probable destruction.



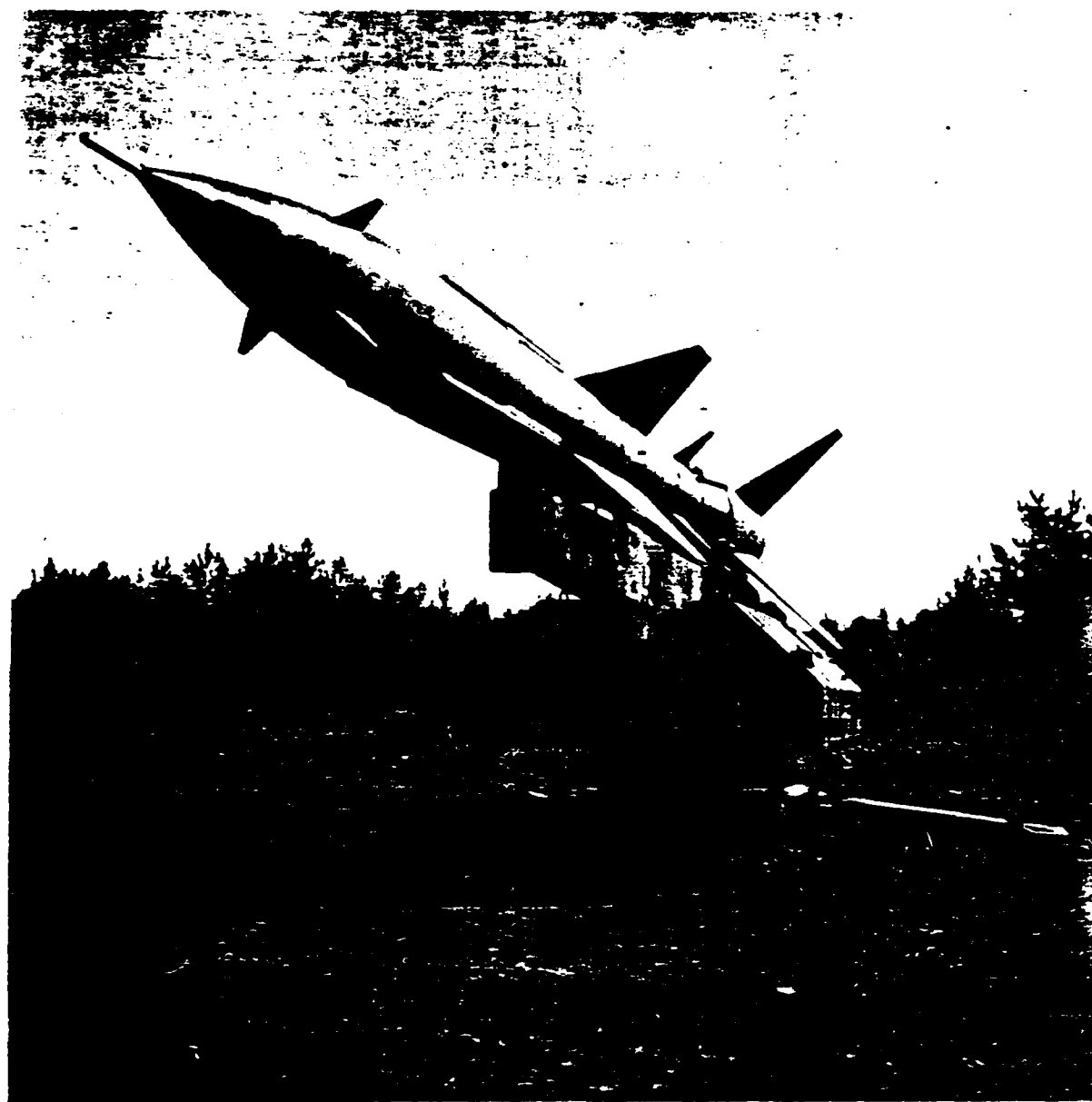
Illustrations of the comparison picturing the development of artillery equipment between 1943 and 1973:

a--the salvo weight of an artillery division; b--the division's equipping with anti-armor devices and the armor pierced by them; c--rapid firing anti-aircraft artillery

1. tons, 2. year, 3. quantity of anti-armor devices, 4. thickness of the armor pierced, 5. rounds/min., 6. year.



At a firing position



An anti-aircraft rocket on a launcher

TABLE 1.4.

| Lp. | Wyszczególnienie parametrów | Wzrost sprzętu | | | | |
|-----|---|-----------------------------|------------------------------|--|-------------------|--------|
| | | art. klas | | działo bezodrzut. 82 mm wz. B-10 | wyrzutnie rakiet. | |
| | | 85 mm armata wz. D-44 | 100 mm armata wz. BS-3 | | WP-2 | 84-14 |
| 1 | Kaliber (mm) | 85 | 100 | 82 | 140 | 140 |
| 2 | Ciężar (kg) | 1725 | 3650 | 86 | — | 3200 |
| 3 | Doność (km) | 15,6 | 20 | 4,47 | 10 | 10 |
| 4 | Szybkość początkowa pocisku (m/s) | 800 | 900 | 322 | 400 | 400 |
| 5 | Ciśnienie maks. w lufie (kg/cm ²) | 2550 | 3000 | — | — | — |
| 6 | Ciężar naboju (kg) | 16 | 30 | 4,2 | 39,6 | 39,6 |
| 7 | Ciężar pocisku (kg) | 9,5 | 15,8 | 3,89 | 31,95 | 31,95 |
| 8 | Odległość strzału bezwzgl. (m) | 950 | 1100 | 350 | — | — |
| 9 | Długość armaty (mm) | 8340 | 9370 | 1910 | 3520 | 6920 |
| 10 | Kąt ostrzału pionowego (stop.) | 42 | 50 | 50 | 50 | 50 |
| 11 | Kąt ostrzału poziomego (stop.) | 54 | 58 | 360 | 30 | 140 |
| 12 | Szybkostrzelność (strzał/min) | 20 | 7 | 11 | 8/10s | 16/10s |
| 13 | Szybkość holowania (km/h) | 60 | 50 | 40 | 40 | 40 |

Table 1.4. Specifications of the basic parameters of some older types of artillery equipment of the Polish People's Army
 1. caliber, 2. weight, 3. range, 4. the projectile's initial velocity, 5. maximum pressure in the barrel, 6. the cartridge's weight, 7. the shell's weight, 8. firing distance, 9. cannon length, 10. vertical firing angle (degrees), 11. horizontal firing angle (degrees), 12. firing rate (rounds/min), 13. transport speed, 14. number, 15. specification of parameters, 16. artillery class, 17. rocket launcher, 18. equipment type, 19. 85 mm cannon (D-44), 20. BS-3 100 mm cannon, 21. B-10 82 mm recoilless gun.

TABLE 1.5.

A. AUTOMATIC WEAPONS.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | | |
|-----|--|-------------------------------------|---------|---------|
| | | 1943—45 | 1955—60 | 1970—73 |
| 1 | Kaliber broni (mm) | 7,62 | 7,62 | 9 |
| 2 | Ciętar bez naboju / z nabojami (kG) | 3,800 | 3,300 | 1,620 |
| | | 5,400 | 3,650 | 2,000 |
| 3 | Długość broni (mm) | 842 | 616,831 | 332 |
| | | | | 580 |
| 4 | Szybkość początkowa pocisku (m/s) | 500 | 500 | 330 |
| 5 | Odległość ognia skutecznego (m) | 200 | 200 | 200 |
| 6 | Ciętar naboju/pocisku (G) | 11,00 | 11,00 | 10,00 |
| | | 5,52 | 5,52 | 6,10 |
| 7 | Szybkostrzelność praktyczna (strzał/min) | 30—100 | 30—100 | 10—100 |

B. RIFLES.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | | |
|-----|---|-------------------------------------|------------------|---------|
| | | 1943—45 | 1955—60 | 1970—73 |
| 1 | Kaliber (mm) | 7,62 | 7,62 | 7,62 |
| 2 | Wzór broni | wz. 91/30 | wz. 38 wz. 44 | kkk AKM |
| 3 | Ciętar broni bez naboju/z nabojami (kG) | 4,0 | 3,9 | 3,500 |
| | | 4,1 | 4,0 | 4,000 |
| 4 | Długość broni (mm) | 1230 | 1020—1333 | 870 |
| 5 | Szybkostrzelność (strzał/min) | 10 | 10 | 600 |
| | | | | 90—100 |
| 6 | Odległość ognia skutecznego (m) | 1000 | 1000 | 600 |
| 7 | Ciętar naboju/pocisku (G) | 21,8 | 21,8 | 16,2 |
| | | 9,6 | 9,6 | 7,9 |

C. ANTI-ARMOR WEAPON.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | |
|-----|------------------------------------|-------------------------------------|---------|
| | | 1943—45 | 1955—60 |
| 1 | Kaliber (mm) | 76,2 | 57 |
| 2 | Ciętar broni (kG) | 1150 | 1250 |
| 3 | Szybkostrzelność (strzał/min) | 15 | 15 |
| 4 | Donośność strzału bezwzględnej (m) | 780 | 1100 |
| 5 | Ciętar pocisku ppanc. (kG) | 6,5 | 3,14 |
| 6 | Grubość przebijanego pancerza (mm) | 61 | 105 |

D. TANK CANNON.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | | |
|-----|--|-------------------------------------|---------|---------|
| | | 1943—45 | 1955—60 | 1970—75 |
| 1 | Kaliber (mm) | 76,2 | 85 | 100 |
| 2 | Ciężar armaty (kG) | 950 | 1150 | 1950 |
| 3 | Szybkostrzelność w miejscu, ruchu (strzał/min) | 15 | 10 | 7 |
| 4 | Ciężar pocisku ppanc. (kG) | 6,2 | 9,2 | 15,88 |
| 5 | Szybkość początkowa pocisku (m/s) | 680 | 792 | 900 |

E. ANTI-AIRCRAFT CANNON.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | | |
|-----|--|-------------------------------------|----------|----------|
| | | 1943—45 | 1955—60 | 1970—75 |
| 1 | Kaliber (mm) | 37 | 57 | 25 |
| 2 | Ciężar (kG) | 2100 | 4500 | 950,0 |
| 3 | Szybkostrzelność (strzał/min) | 160—180 | 105—120 | 1000 |
| 4 | Doność pionowa (pułap) (m) | 6700 | 8800 | 1500 |
| 5 | Ciężar pocisku (kG) | 0,758 | 2,800 | 0,19 |
| 6 | Szybkość naprowadzania poz. w stopniach na sekundę pionow. | 15 75 | 30 18 | 60 40 |

F. ROCKET LAUNCHERS.

| Lp. | Wyszczególnienie danych | Wzory będące na uzbrojeniu w latach | |
|-----|-------------------------|-------------------------------------|---------|
| | | 1943—45 | 1955—60 |
| 1 | Kaliber (mm) | 132 | 140,3 |
| 2 | Ciężar broni (kG) | 6200 | 8200 |
| 3 | Doność maksymalna (m) | 8470 | 10 000 |
| 4 | Szybkostrzelność | 7,10 s | 7,10 s |
| 5 | Ciężar pocisku (kG) | 42,5 | 39,6 |
| 6 | Ciężar salwy (kG) | 680 | 633,6 |

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Table 1.5. Comparative data for development of firearms in the Polish People's Army

A. automatic weapons

1. firearm caliber, 2. weight without cartridge/with cartridge, 3. firearm length, 4. projectile's initial velocity, 5. effective firing distance, 6. cartridge/projectile weight, 7. practical firing rate (rounds/min), 8. number, 9. data specification, 10. weapons existing in the arsenal during the years

B. rifles

1. caliber, 2. firearm type, 3. firearm weight without cartridge/with cartridge, 4. firearm length, 5. firing rate (rounds/min), 6. effective firing distance, 7. weight of cartridge/projectile, 8. number, 9. data specification, 10. weapons existing in the arsenal during the years

C. anti-armor weapon

1. caliber, 2. weapon's weight, 3. firing rate (round/min), 4. firing range, 5. weight of anti-armor projectile, 6. armor penetration thickness, 7. number, 8. data specification, 9. weapons existing in the arsenal during the years

D. tank cannon

1. caliber, 2. cannon weight, 3. firing rate in place/moving (round/min), 4. anti-armor shell weight, 5. projectile's initial velocity, 6. number, 7. data specification, 8. weapons existing in the arsenal during the years

E. anti-aircraft cannon

1. caliber, 2. weight, 3. firing rate (round/min), 4. vertical range (ceiling), 5. projectile weight, 6. aiming speed in degrees per second, horizontal, vertical, 7. number, 8. data specification, 9. weapons existing in the arsenal during the years

F. rocket launchers

1. caliber, 2. weapon's weight, 3. maximum range, 4. firing rate, 5. projectile weight, 6. salvo weight, 7. number, 8. data specification, 9. weapons existing in the arsenal during the years

1.4 ROCKET WEAPONS OF THE CONTINENTAL ARMY

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The first rocket weapon used by the Polish People's Army was the "katiusza" made famous in World War II--the BM-13 rocket projectile artillery launcher, to use the contemporary nomenclature. This self-propelled launcher was characterized by its great mobility arising from the utilization of a self-propelled land vehicle, and simultaneously--its great fire power: a full salvo of 16 projectiles from all its guides could be delivered in 10 seconds. The M-13 projectile, propelled by a solid fuel rocket motor, achieved a range of 8.5 km, and its warhead corresponded to that of a classic medium caliber artillery shell. Thanks to this, the fire power of one such launcher was equal to that of the salvos of 16 guns.

The M-13's drawback was its considerable dispersion, arising to a great extent from the principle of shaft stabilization used in it. Therefore, projectiles, stabilized during flight by a rotating motion caused by the oblique arrangement of the additional, lateral nozzles of the rocket motor, were used in the new launchers introduced into the Polish People's Army in the 1950's. Such a projectile design allowed the use of tubular guides in the launchers, which also helped to diminish the projectiles' dispersion. For special needs, a light launcher was designed on a two-wheeled vehicle. This launcher could be moved by the GAZ-69 land vehicle; it could also be transported by air and dropped by parachute.

Rocket launchers are formidable weapons. From both the point of view of range and destructive power, they play a role similar to that of classical artillery. Thanks to their firing rate, they make up a valued complement to classical artillery, guaranteeing the carrying

out of the intensive, mass bombardment of surface targets.

The completely new quality rocket weapons, which can perform tasks that classical artillery cannot, are the tactical and operational-tactical rocket projectile.

Tactical rocket projectiles with warheads of great destructive power make possible the engagement of the enemy's reserves, the position of his rocket weapons or that of his command, his transport, bridges and other objects which lie outside the range of classical artillery. These projectiles are propelled by solid fuel rocket motors. This ensures simple maintenance and great operating reliability. They are fired from self-propelled mobile launchers, capable of operating even in difficult terrain. The Polish People's Army possesses tactical rocket projectiles both on tracked and wheeled launchers.

Operational-tactical rocket weapons make up the most potent weapons of the continental army, designated for overpowering and destroying important targets which lie in the enemy's rear: large massed armies, communication networks, air strips, etc. These weapons can carry out their mission thanks to their great range and accuracy, arising from the use of programmed guided systems. These are, therefore, technically highly complex devices, and their firing preparation requires the performance of a series of complicated operations. Nevertheless, the units of operational-tactical rocket projectiles used in the Polish People's Army are very mobile. All of their elements are mounted on self-propelled, tracked or wheeled vehicles. This allows the easy and rapid change of firing positions.

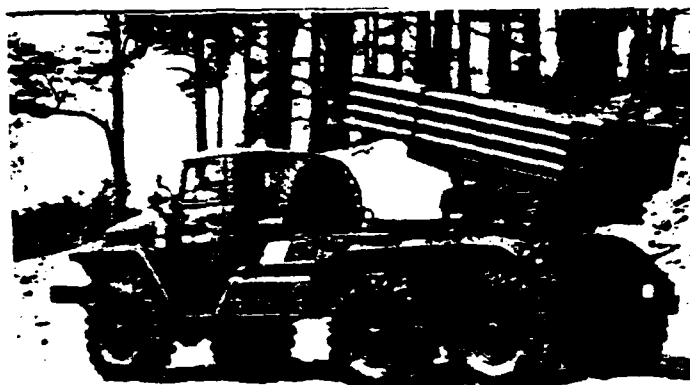
Directed anti-armor projectiles were introduced into the Polish People's Army simultaneously with the tactical and operational-tactical rocket projectiles. They have completely revolutionized anti-armor defense because they make possible the engaging of armored targets at distances unreachable by classical anti-armor artillery and with greater accuracy. This accuracy is obtained thanks to the use of control systems during flight. At the same time, these projectiles are so small and light that they are fired from launchers mounted on light amphibious armored transports, which insure them a great maneuverability on the battlefield. The guided anti-armor projectiles are propelled by solid fuel rocket motors and are equipped with accumulative warheads with great destructive power, allowing the piercing of the armor of every tank.

The use of rocket weapons in anti-aircraft defense has caused the greatest revolution. The introduction of this weapon was occasioned by necessity, because classical artillery could not guarantee the engagement of the enemy with such fast flight and such a ceiling as modern airplanes have been able to achieve, not forgetting unmanned means of air attack. An additional task of anti-aircraft defense is the engagement of the aircraft at a distance sufficiently removed from the defended object, because they can attack the target with air-to-surface rockets, even at considerable ranges.

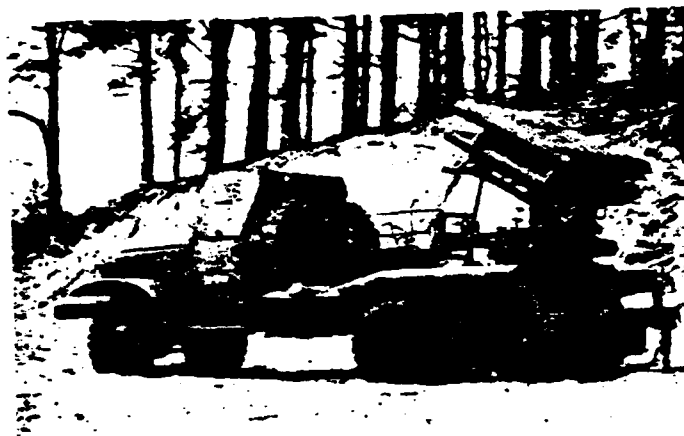
The solution of all these problems became possible thanks to the use of anti-armor rocket projectiles. Rocket propulsion makes possible the attaining of the necessary velocity, ceiling and range, and the remote control systems insure great accuracy. Anti-aircraft rocket systems are equipped with radar stations, tracking the target, and with computers, and are completely automatic, which insures the necessary operating speed.

The rocket weapon is found, as before, in an intensive developmental state. The result of this is the introduction of newer, better types. The rockets' range has been constantly increased by using more efficient fuel and decreasing the motors' weight. Accuracy has been improved as a result of the perfecting of guiding systems. At the same time, as the result of the introduction of new materials and modern technology both the rocket projectiles as well as the equipment included in rocket units are more simply designed, more capable and more reliable. - [

The rocket weapon, and especially the guided rocket, requires highly trained personnel. The training of the personnel should proceed under conditions as real as those during the weapon's actual use. The organization of the training base was, therefore, one of the basic tasks facing the army at the time of the introduction of rocket weapons. In order to insure the proper training process, and at the same time to lower, to the extent possible, its costs, a series of auxiliary training devices was designed, which faithfully recreated battle conditions.



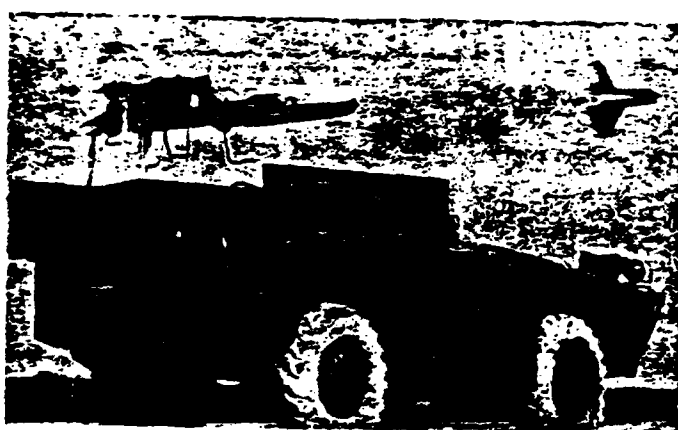
The BM-21 launcher



The BM-14 launcher



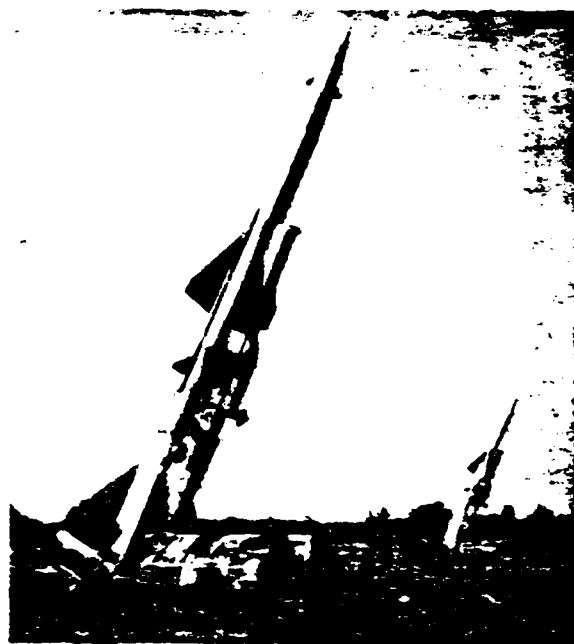
The WP-8 launcher



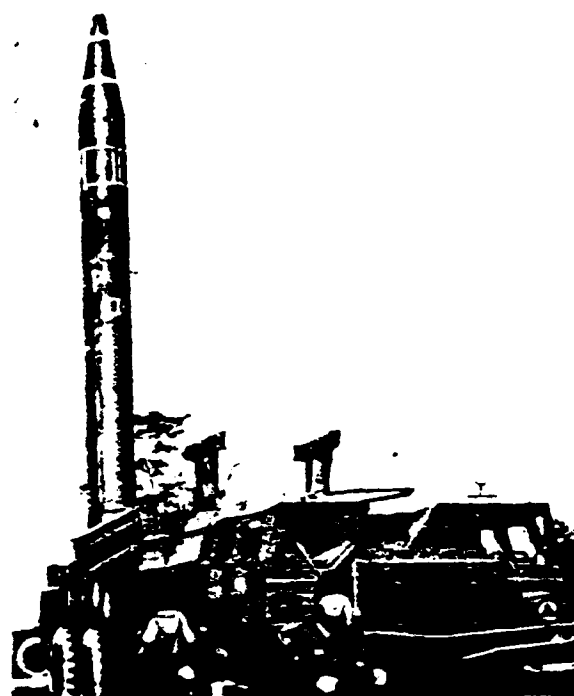
The 2P27 launcher



A guided anti-armor unit



Guided anti-aircraft rockets



A surface-to-surface rocket

1.5 OPTICAL-MEASURING AND NIGHT VISION EQUIPMENT

Optical and night vision instruments have found broad application in the military and in military technology, especially in weaponry. Beginning with binoculars, which are included in the individual equipment of the command grades in the army, cannon and tanks, armored transports, naval craft, aircraft and helicopters, mechanical vehicles and a series of rifles are equipped with optical and night vision instruments. This type of equipment has a very real importance in military operations, and even determines, to a great extent, success on the battlefield. Because of their precise study of the terrain, optical devices make possible the precise aiming of weapons at enemy targets, measuring of angles and determining of distances.

Night vision instruments play a similar role in nighttime conditions, which, besides the already mentioned functions, find broad application in the operation of mechanized and battle vehicles in darkness.

Optical devices are used in daytime operations, while night vision ones, as already mentioned, are used in conditions of darkness. Therefore, the use of these two basic types of equipment during the mentioned 30 year existence of the Polish People's Army will be treated separately.

In the thirty years of the existence of the Polish People's Army, four basic types of optical equipment have been introduced: observation devices, sights, range finders and measurement devices.

To the first group belong field glasses, binoculars and periscopes. These devices make possible the : discovery and study of the targets, observation of the battlefield and the correction of artillery and rifle fire. These devices can also perform crude angular and distance measurements. The mentioned optical devices yield an especially great service when the discovery and study of the target is difficult or completely impossible for the naked eye. For this reason, binoculars, observation periscopes etc. make up the basic equipment of every unit. 42

Tank observation devices (observation periscopes) also play an essential role. With their aid, tank crews can observe in battle conditions the battlefield from inside the vehicle. This type of equipment was already used to a limited degree in World War II.

In the post-war period the given number of types of devices increased, their design was improved as were their technical-optical characteristics. The observation devices introduced as equipment are resistant to radioactivity, which has an essential significance for the modern battlefield.

The second group of optical devices--sights, has , above all, broad application in military equipment. Sights are included in the equipment of rifles, guns, tanks and armored transports, as well as other battle vehicles. The deck weapons of airplanes, helicopters and naval craft also are equipped with optical sights.

These devices make possible the observation of the battlefield and the subsequent firing of rifles and artillery. The introduced sights are characterized, above all, by great precision, a large angle of the field of vision and a great penetrability of the optical system, which guarantees its usefulness under various atmospheric conditions and every time of day. A series of sights has been adapted to nighttime targeting.

Range finders make up the third group of optical devices. These include very precise optical military devices. These devices serve for the measurement of distances and horizontal and vertical angles, the determination of the site of the projectile's explosion and the observation of the battle field. Moreover, target coordinates can be determined. Range finders have found the broadest application in land and anti-aircraft artillery units, which can fire at targets found at considerable distances and heights. The distance is the parameter necessary for the proper aiming of whatever sighting devices of weapons (the selection of the corresponding values of the sighting scale), for which its precise determination decides the fire's effectiveness.

During the last 30 years many types of these devices have been introduced into the Polish People's Army for different purposes.

The last two years have seen a further development in the equipment for distance measurement. Laser devices insure a very high level of precision, independent of the distance to be measured.

The theodolite belongs to the basic measuring equipment, mentioned

earlier. With the aid of theodolites it is possible to measure the vertical and horizontal angles with great precision and calculate the azimuths on the basis of observing the sun or the stars. When additional equipment is used it is possible, moreover, to measure distances with them. These measurements have a vital importance in individual rocket and artillery units.

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Four basic groups of equipment introduced into the Polish Army stem largely from domestic production. The realization of this production and the satisfying of the army's need in this period was made possible thanks to the development of the optical industry in the post-war period. The training of highly qualified specialists, both in the optics industry and in the civilian scientific-research centers as well as in the army, also had an unquestionable importance. Besides production questions, the army attaches great significance to developmental work, whose goal is the introduction of better equipment. The fundamental work in this area tends to the direction of the miniaturization of optical equipment, and especially rifle sights, the utilization in optical devices of the largest possible angle of the field of vision as well as the improvement of the production technology of laser equipment.

Independent of this the perspective direction of work consists of stabilized optical systems, and also systems with variable magnification. The use of these systems has allowed the designing of devices which allow the observation from mechanical vehicles while on the move and from helicopters. The greater use of plastics, moreover, is anticipated for the design of these devices.

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NOCTOVISION DEVICES

Noctovision devices and instruments were introduced into the Polish Army during the post-war period. These allowed the performance of battle operations at night without the use of light sources visible to the naked eye.

The noctovision devices used in the Polish Army are divided into two basic groups: noctovisor sights for rifles, artillery, the deck guns of battle craft and nighttime sights for operating mechanical vehicles and observation. Independent of these two groups is the use of various modifications of this equipment, for example, for engineering activities at night.

Nighttime sights are characterized by good tactical-technical properties, and especially by a significant range of vision.

Noctovisors also make the operation of vehicles possible at night. For example the driver's noctovisor allows the observation of the individual silhouettes of people or objects at distances of up to 150 m. The vehicle's driver, equipped with this type of noctovisor, can reach a road speed of 80 km/h.

The vehicle's reflectors, which are covered with infra-red filters, are the source of the infra-red rays in this instance. Independent of the mentioned functions, this noctovisor--with additional equipment--can be used for reading maps and texts, and for repairing the vehicle in the dark.

These cited types of noctovision devices are, as with the optical devices, for the most part, produced domestically. The mastering of its production technology is one of the great achievements of Polish technological thought. Independent of present achievements, intensive work to perfect noctovision equipment continues as before. The main direction of this labor has tended toward miniaturization, increasing the angle of the field and range of vision by the use of highly efficient infra-red ray sources.

1.6 RADAR SOURCES

The rapid development of radar during the Second World War, as well as in the post-war years was tied, above all, to the military use of radar technology. This was caused by the dynamic development of the means for air attack: jet aircraft and rocket weapons. Radar equipment is usually a necessary element of the equipment of every modern army. It makes up the basic equipment of all types of armies, and especially the country's air defense forces, its rocket and operational forces, its navy and border forces.

There are also numerous civilian uses for radar equipment. Above all, radar equipment is universally used in the control of air traffic at civilian airports. It is also used for sea and river navigation, meteorology and controlling road traffic.

During its many years of existence radar has been developed at an uneven rate and at varied schedules. After its rapid and manifold development during World War II, several years ensued in which the

equipment's design was perfected, introducing neither new methods nor designs.

New requirements connected with the development of aircraft and rocket technology forced the design bureaus to seek completely new methods, as well as the radical correction of the equipment's basic parameters. From then on until the 1950's and 1960's, there ensued a rapid development of radar technology, both within the realms of methods and systems, as well as in equipment technology and design. We can cite here such achievements as the design of coding and impulse compression methods, new warfare methods with atmospherics, the altering of impulses for impulses, diversity frequencies, mono impulse methods, the electronic exploration of space, low noise receivers, high power coherent transmitters, the introduction of secondary radar--a station which simultaneously determines the three coordinates of numerous targets, the automatic processing of radar information and many others.

The present period in radar technology is characterized mainly by the development and improvement of design methods of the 1960's and the perfection of the equipment's design and technology. As opposed to the previous period, the newly designed methods and systems have not been commonly introduced into practical use; rather, a period of the evolution and maturation of solid equipment has ensued.

POLISH SCIENTIFIC-TECHNICAL THOUGHT IN THE FIELD OF RADAR

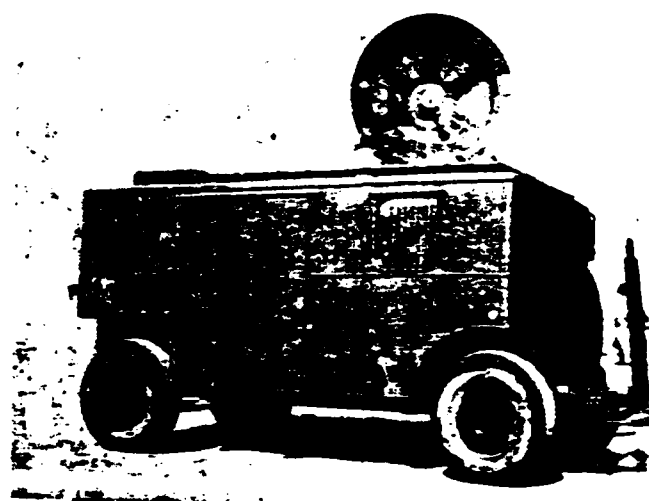
The outbreak of World War II and the multiyear Hitlerite occupation hindered the development of technical thought in Poland. The

montrous destruction and plunder of the scientific-research apparatus generated the necessity of rebuilding and developing scientific-research institutions and industries from the ground up. Therefore, the first radar device, with which the Polish People's Army was equipped during the war, was imported. Despite the massive destruction which took place in World War II, thanks to the assumption of power by the working class and to the help of the Soviet Union, the rapid reconstruction and expansion of scientific-research institutions and the national defense industry occurred. Beginning in 1949, the first scientific-research centers occupied with radar appeared. The operation of industrial factories specializing in this area began shortly thereafter. These factories undertook the production of modern radar, in the initial period on the basis of licenses, and later on the basis of domestic designs. In the 1950's was begun the domestic production of radar stations for the guiding of artillery fire, as well as for warning, discovery and direction. The characteristics of Polish produced radar stations given below are an example of the development and achievement of Polish scientific-technical thought in the field of radar.

Radar stations for guiding fire are designed for the discovery and continuous tracking of air targets, and also for the transmission of the target's existing coordinates to artillery computers. These computers determine the special data for guiding the firing. In connection with this, the station's operating range depends upon the possibilities of the anti-aircraft artillery's initiating accurate firing at maximum range.

The radar station operates in two basic modes: discovery and tracking. In the discovery mode, the areal search is carried out manually or automatically. In this operating mode, the target's

coordinates (distance, azimuth and positional angle) are roughly determined. This station's discovery range is considerable. After the target is discovered and the decision to attack it is made, its automatic tracking then follows. The station, operating in the tracking mode, determines the target's coordinates with a precision sufficient for accurate firing. The range of the station, operating in the tracking mode, is approximately two time less than that when operating in the discovery mode.



An artillery radar station for guiding firing

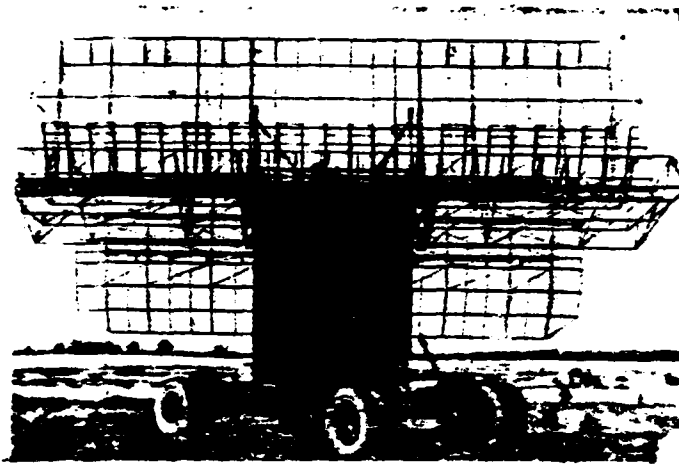
Stations designated for the guiding of firing in the tracking mode determine all the coordinates with great precision: the distance, azimuth and the target's positional angle. They determine the distance with an accuracy of several or several tens of meters, and the angular coordinates--with an accuracy of tenths and even hundredths of a degree. These stations cooperate in a system with preliminary aiming stations.

Warning radar stations as well as discovery and aiming stations can perform the following tasks:--depending upon the type of force in which they are used:

- to distinguish enemy aircraft in order to inform the army and objects of an impending air attack;
- to direct friendly fighter planes to enemy aircraft;
- to indicate the target to radar stations directing the firing of anti-aircraft artillery.

Radar stations for the discovery of airborne targets are used, above all, to distinguish enemy aircraft and to warn the system of defense of the threatened air attack. The main parameter of this type of station is the discovery range, which--as is evident--depends among other things upon the altitude of the target's flight and the properties of its radio wave deflection (from the surface of the actual target). These stations determine two coordinates: the azimuth and the distance, and if it works with an altimeter, a third target coordinate--altitude. The radar station which plays the role of altimeter has a special antenna, emits a beam of very narrow electromagnetic waves into space in a vertical and wide plane, and in a horizontal plane. This antenna can be turned on the azimuth and swung into the positional angle.

Based on the data used from the radar station for discovering the target, the altimeter's antenna follows the target into the azimuth and, swinging into the positional angle, determines the target's altitude. Based on the target's distance and positional angle coordinates, its altitude is automatically determined by a computer.



The Nysa warning radar station.

One of the stations for discovering airborne targets and guiding the active means of air defense has been designed and is being developed in Poland.

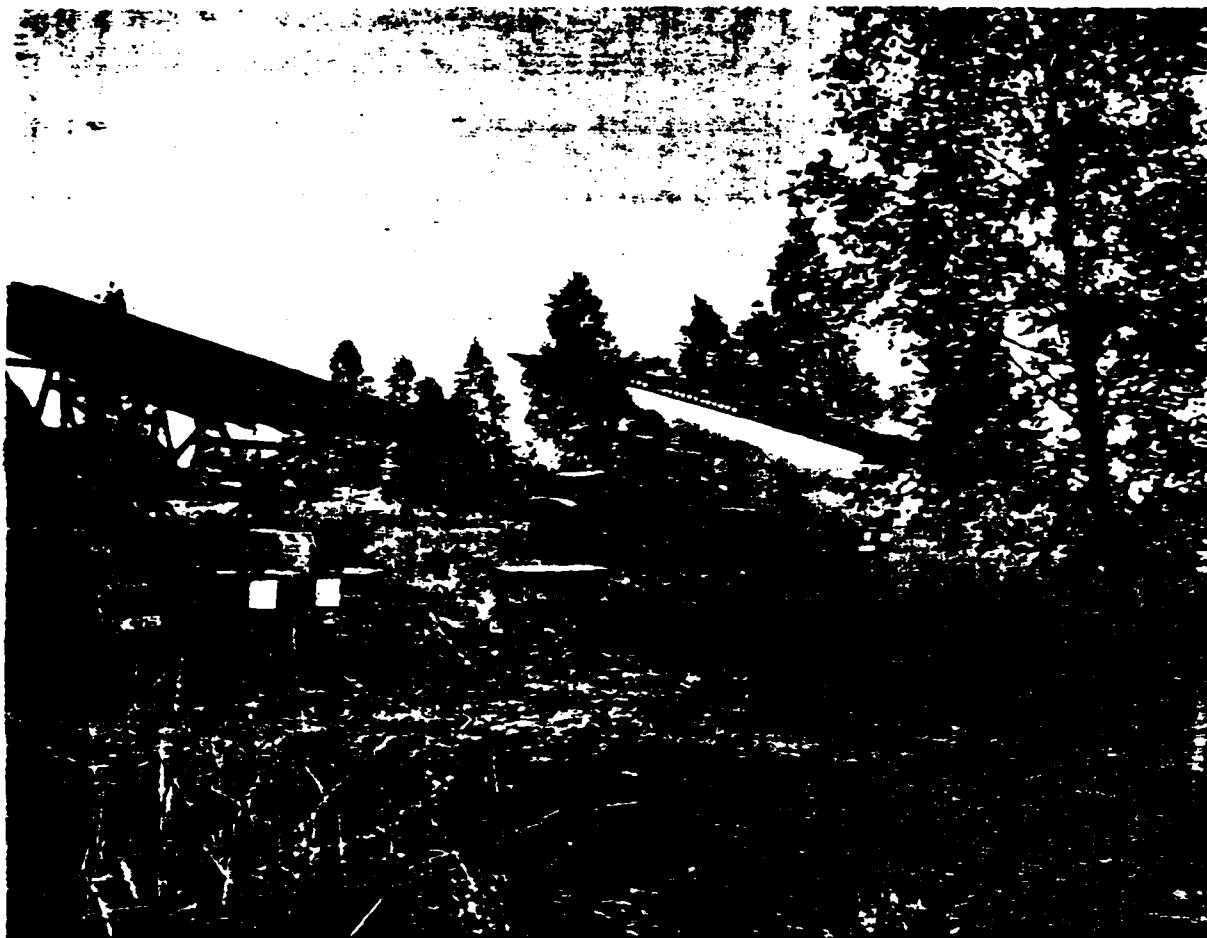
Also, a series of stations for the control of air traffic and marine navigation--both sea and river--has been designed in Poland. For example, the AVIA radar station for regional control has a modern design consistent with the contemporary trends in the development of radar technology. A parametric amplifier on a varactor diode is used in reception systems. It has a noise coefficient of 3.5 dB. Videodiversity systems insure the optimum signal accumulation from the two reception channels. The station is equipped with an echo attenuation apparatus with a static attenuation efficiency of 30 dB. The apparatus uses a commutative reduplication frequency, a system of automatic amplification equalization and the possibility of the regulated inclusion of the return connection.

The panoramic indicators consist of a picture tube with a 31 cm diameter in a system with fixed tubes. These indicators are equipped with electronic azimuth and distance gauges, and an electronic course line system for the designation of coordinates from an arbitrary point on the screen.



Surface-to-surface tactical rocket

48A



The firing of a rocket

48B

Several series of transistorized navigation radar systems were designed in Poland. The TRN 400 series navigational instruments are

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intended for installation in average sized units.

These radars are characterized by their modern design and outstanding exploitation properties. Three impulse duration periods ("latitudes"), two reduplication frequencies and eight observation scopes make possible the reception of the optimal picture at every observation scope.

The TRN 500 series navigational radars are intended for installation on large marine units. The basic characteristics of the device include an indicator with a sixteen inch screen, seven observation scopes, three test impulse duration periods (from .1 to 1 μ s), true resolution with automatic return to the basic starting point, as well as relative resolution and great range potential

Only a few of the achievements of the scientific-research institutions and domestic radar industry, making an essential contribution to the arsenal of the Polish Army, can be mentioned here.

RADAR EQUIPMENT IN THE POLISH PEOPLE'S ARMY

Modern military operations are characterized by the use of various types of forces richly equipped with new technology. These operations are marked by great dynamism, mobility and decisiveness. The introduction on to the battlefield of weapons of massive destruction has created new, important demands on the planning and organization of military operations as well as on the performance of these operations. In connection with this, the tasks of technical

supply have been considerably complicated. The role of such technical tasks, as reconnoitering the enemy by land and air, anti-aircraft and anti-rocket defense and the rigorous and continuous guiding of forces, has especially grown. These tasks have to be performed even under conditions of limited visibility, at night, in the fog, in smoke screens.

Radar occupies a special place among the many modern discovery and guide systems. These systems are included in the equipment of all branches of the Polish People's Army. These include domestically produced and imported radar systems. Presently, they are used for various tasks. These devices, for the most part, do not operate independently, but are elements of systems which perform various functions, such as the discovery of a target and guiding ones own forces against it.

Depending upon the system's designation and function, various radar devices are used. Long-range radar is found within the discovery and targeting systems. These devices have powerful receivers and large dimensioned antennae. These stations are often situated near the country's border. Their task is, most often, to discover the enemy's battle forces and to attack them.

Contemporary radar allows the enemy's discovery before he crosses the lines of defense. As the enemy targets approach the lines of defense, the station transmits the data to devices which target anti-aircraft defenses. These, possessing a smaller discovery range, determine the target's precise coordinates, allowing air defenses (for ex. fighter planes) to be aimed at the target and its tracking by radar located on the aircraft. When the airborne radar detects the target,

targeting is carried out on the ground: the fighter itself begins to approach the target and crosses over to the attack. Not seeing the target, the pilot can aim his weapons when all the data concerning the target's position is in analog form shown on his indicator screen or given numerically on the appropriate instruments. The pilot's task consists only of choosing the right moment to commence firing.

A special computer performs this task in some airplanes. Besides this, on some airplanes are installed a series of different radar devices, such as "firing defense" radar, circular observation radar and radar sights. All radar devices found in individual aircraft have instruments for target identification. The device's receiver gets a signal from the radar station and activates its transmitter. The identification signal is sent in the station's direction close behind the reflex signal. Then, together with this signal an additional signal from the target is received telling whether the given object is "ours". If the enemy can not send such a signal, he is correspondingly coded so, and the receiver is coordinated so that only properly coded signals can enter it.

Rocket forces, besides being the army's youngest, occupy first place in regard to the use of radar. All the tasks performed by them are tied to radar.

Rockets must be guided throughout their entire flight. Computers calculate the course of flight of both the rocket and its target and transmit by means of radar devices the signals containing the course's dimensions and flight velocity; the radar station operates up to the moment when the blips representing the target and rocket meet on the screen in an echo, which means the target's destruction by the

rocket. This task cannot be performed by one radar station. A system, comprised of a series of radar stations and computers, which control and transmit data, is necessary.

Radar equipment is also widely used in the Navy. Modern ships are equipped with one or even several radar stations.

We must also mention naval aircraft radar and that found on helicopters for the detection and destruction of submarines.

Systems, whose task is to "process" information and control attack weapons, assure the proper use of the information worked out by radar equipment.

Land forces (which have not for a long time had an infantry in the traditional sense) are also equipped with mobile radar equipment. This has been adapted to wheeled, rail and air transport. The army also has stations adapted to human transport. Presently, reconnoitering the battlefield without the use of radar equipment is unthinkable. Radar allows observation of the battlefield under various meteorological conditions as well as during the night.

Anti-artillery radar, besides reconnoitering and detecting firing positions, also plays another very important role. It warns its own army of the beginning of the enemy's artillery and rocket fire.

This equipment, observing in a continuous manner the course of a detected

flying shell or rocket, begins to track them and determines firing coordinates. These are then transmitted to a computer, which in the course of a few seconds calculates the entire trajectory (as a curve) of the projectile's flight and determines the place from which it (the shell or rocket) was fired. The data concerning the location of the enemy's firing position is sent to the artillery, which immediately begins firing at the enemy's positions.

The same station, which has determined the enemy's position, directs the fire of its own artillery, tracking the course of its own shells. It also determines where they will fall and works out the appropriate corrections.

The land forces, as well as other types of forces, are also equipped with radar for observation, areal search, the detection of airborne targets and the targeting of anti-aircraft defenses.

Frontier defenses, especially on the sea and river borders, have also been equipped for several years with radar. This equipment not only allows the control of the traffic navigating territorial waters, but can detect at considerable distances fishing boats, skiffs, canoes and even people swimming. The positioning of a net of radar sentries on the state's frontiers assures its reliable defense in various meteorological conditions (fog, rain) and at night.

The classification of equipment in this chapter made from the point of view of its affiliation to a specific type of military force is indeed arbitrary. Some similar devices are used by various types of forces and some are difficult even to tie to a certain type. In essence,

really all of the mentioned types of radar equipment operate in systems, which make rapid decisions (about the manner of attack) possible, and direct equipment used for the attack of a determined target. Radar is a sure and necessary ally for all types of forces, because it defends against surprise attack and significantly increases the power and strength of the operations of a modern force, such as the Polish People's Army.

2. TANK EQUIPMENT

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2.1 TANK EQUIPMENT OF THE POLISH PEOPLE'S ARMY BETWEEN 1943 AND 1945

The division and units of the Polish People's Army formed during World War II were equipped with Soviet battle equipment. The Soviet Union produced then tanks and light, medium and heavy self-propelled armored guns. On the whole, 23 varieties of tanks and armored guns were produced during this period. The range of types in the field of battle vehicles was caused by the need for their rapid improvement and adaptation to the actual demands of war. The principle of building battle vehicles on the base of those vehicles already recognized as successful was taken into the developmental design.

During 1943 3 types of battle vehicles existed: the T-70 light tank, the T-34 medium tank and the KW heavy tank. These made up the basis for the building of even better armored equipment. Light self-propelled guns were built on the chassis of the T-70, medium type tanks and self-propelled armored guns on the chassis of the T-34 and heavy tanks and self-propelled guns on the KW tank's base.

The main directions in the development of battle vehicles were: increasing the power and firing unit and the armor's resistance to enemy armor piercing weapons while maintaining a sufficient mobility. In evaluating the quality of the design, production and battle worth of the armored equipment of those days, it is necessary to ascertain if that was high class equipment.

During World War II, the Soviet Union had at its disposal 26 types of

heavy vehicles and tractors, which were not produced in sufficient quantity to entirely satisfy the need. Despite these difficulties, the Soviet Union obligated itself to equip the divisions and tactical and operational units of the Polish Armed Forces.

On May 15, 1943, the Tadeusza Kosciuszki First Infantry Division (1 DP) was formed at Sielci nad Oka. It consisted of 3 infantry regiments, one tank, light artillery and fighter plane regiment each, two mortar units and a student and women's battalion, as well as specialized subunits.

The First Heroes of the Westerplatte Tank Regiment, formed within the framework of the 1 DP's organizational structure, was the embryo of the Armored and Mechanized Forces of the Polish People's Army. The 1st tank regiment was composed of the following battle subunits: 3 T-34-76 medium tank companies, one T-70 light tank company, a rifle company and an anti-armor gun company. This regiment's weaponry consisted of 32 medium tanks, 10 light ones and 3 BA-64 armored cars.

On August 19, 1943, the formation of the First Corps of the Polish Armed Forces (KPSZ) was begun. The First Armored Brigade entered into the framework of the corps, formed on the basis of the First Tank Regiment. The 1st Brigade's striking forces consisted of 3 T-34 medium tank battalions (65 pieces) and one motorized infantry battalion.

From its organizational make up, the 1st KPSZ was composed of a powerful, tactical force, possessing all types of units. The Polish Armed Forces was able to further expand on the basis of individual

types of units. The decision taken on April 1, 1944 led to the transformation of the 1st KPSZ into the 1st Polish Army.

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The organization of the First Armored Corps was foreseen in the plans for the formation of the 1st Army. The Armored and Motorized Forces Division was appointed to the General Staff in order to facilitate the formation of armored and motorized units. The armored and motorized forces, growing in number and quality, began to play a more important role as a fighting unit. Evaluating the import of these forces, Order #053 of May 17, 1944 created the Armored and Motorized Forces Command. In this way a new type of force was created in the Polish Armed Forces.

The liberation of the eastern part of Poland in the second half of July created the conditions for the expansion of the Polish Armed Forces. On July 22, 1944, the Polish National Liberation Committee announced its Manifesto, in which it emphasized that the principal task of the Polish people is to effectively increase its contribution to the country's total liberation, as well as defeating Hitlerite Germany. The High Command of the Polish Army in order #8 from August 28, gave instructions for the formation of the 2nd Polish Army.

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With regard to the personnel difficulties, the 2nd corps was limited to 4 infantry divisions, one armored brigade, one heavy tank regiment, one armored artillery regiment, one heavy artillery brigade, an anti-aircraft artillery division, a mortar regiment, an engineering brigade and security units. As a result, the 1st Polish Army, in comparison with Soviet armies, by its organizational structure, resembled an infantry corps, powerful in its infantry formations, but at the same time dependent upon the support of armored and artillery

forces of a higher grade.

The armored forces of the 2nd Army were composed of: 16 armored brigades, 4 heavy tank regiments and 28 armored artillery regiments. The armored forces possessed a total of 65 medium tanks, 21 heavy tanks, 21 medium armored guns and 5 armored cars.

At the same time, the difficult process of creating the 1st Armored Corps continued. At the end of December 1944, the personnel state of the corp reached a permanent status. In January and February 1945, the armored corps received a full complement of armored equipment and a significant part of the anticipated permanent automobiles from the Soviet Union. Ultimately, the formation of the corps was completed with success. The 1st Armored Corps possessed newly produced armored equipment and was made up of powerful tactical units of armored and motorized forces. It possessed 273 tanks and armored guns, 78 armored cars and transports as well as powerful artillery, including 8 M-13 rocket launchers. Moreover, 804 various motor vehicles were found in the corps.

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In the first half of March, the 1st Armored Corps was subordinated to the 2nd Army.

The battle divisions of the 2nd Army, at this time, had a total of 341 tanks and armored guns, 86 armored cars and transports, 2157 motor vehicles of various kinds as well as around 190 motorcycles. The Corps' command possessed 3 U-2 airplanes. The 2nd Army became a powerful tactical force.

At this same time the 1st Polish Army increased the number of vehicles in its battle units to 2288.

A comparison of the equipment of the 1st and 2nd Armies when they obtained complete battle readiness, shows a quantitative and qualitative change in the development of the Armed Forces of the Polish People's Army. Stress was placed above all on the development of armored and motorized forces. This development led in two basic directions: the increase of fire power by the introduction of a new type of fighting equipment with larger caliber weapons; the increase in mobility by equipping battle units with motor vehicles.

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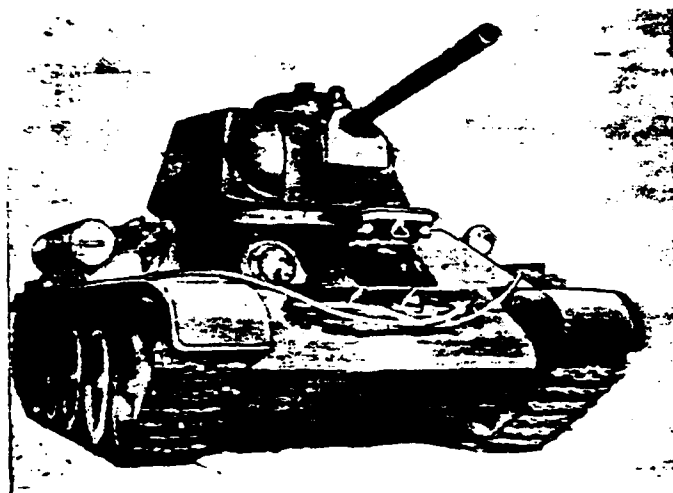
TABLE 2.1.

[illegible]

(See next page for keys.)

The T-34-76 tank

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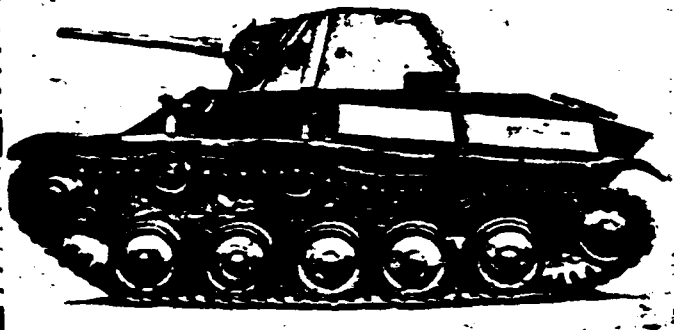


p.59

The IS-2 tank



p. 56-57
Table 2.1 The tactical-technical specifications and characteristics of tanks produced in the USSR during World War II
1. type, 2. light tanks, 3. title, 4. amphibious, 5. production year, 6. chassis, 7. weight, 8. crew (persons), 9. armament, 10. gun, 11. caliber, 12. unit of fire (round), 13. machine gun (round/cal), 14. mobility, 15. max. speed, 16. average unit pressure, 17. unit power, 18. range, 19. surmounted obstacles, 20. slope, 21. trenches, 22. bulkheads, 23. moats, 24. engine, 25. type, 26. model, 27. number of cylinders, 28. max. power, 29. carbureted, 30. compression-ignition, 31-32. carbureted, 33. compression-ignition, 34. speed in water, 35. engines each with a power of 70 KM, 36. medium tanks, 37. heavy tanks, 38. howitzer, 39 amphibious.



The T-70 tank



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The T-34-85 tank



The T-54 A tank

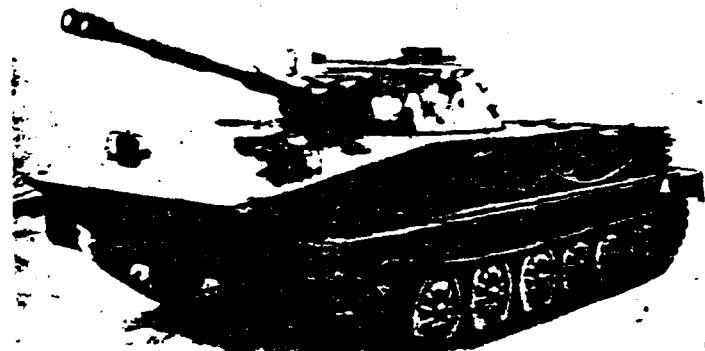


The T-55 tank



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The IS-3 tank



The PT-76 tank

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Table 2.2 The tactical-technical specifications and characteristics of self-propelled armored guns and armored cars produced in the USSR during World War II.

1. title, 2. light, 3. medium, 4. heavy, 5. light armored car, 6. production year, 7. chassis, 8. weight, 9. crew (persons), 10. armament, 11. gun, 12. caliber, 13. unit of fire (round), 14. machine gun (round/caliber), 15. mobility, 16. max. speed, 17. average unit pressure, 18. unit power, 19. range, 20. surmounted obstacle, 21. slope, 22. trenches, 23. bulkheads, 24. moats, 25. engine, 26. type, 27. model, 28. number of cylinders, 29. max. power, 30, 31 and 38. carbureted, 32-37. compression-ignition, 39. engines each with a power of 70 KM

| 1 Nazwa | 2 Lekkie | | 3 Średnie | | | Ciężkie | | | Lekki samochod pancerny |
|--------------------------------|-------------------|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------------------------|
| | SU-37 plot. | SU-76 | SU-85 | SU-100 | SU-122 | ISU-152 | ISU-122 | ISU-152 | BA-64 |
| Rok produkcji | 1942 | 1942—43 | 1943—44 | 1944 | 1943 | 1943 | 1944 | 1944—46 | 1943—44 |
| Podwozie | T-70 | T-70 | T-34 | T-34 | T-34 | KW | KW | IS-2 | |
| Ciężar (T) | 10,5 | 11,2 | 29,6 | 31,6 | 30,9 | 45,5 | 46 | 46 | 2,4 |
| Załoga (osób) | 6 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 2 |
| Uzbrojenie: | | | | | | | | | |
| działo: — kaliber (mm) | 37 | 76,2 | 85 | 100 | haub. 122 | haub. 152 | 122 | haub. 152 | |
| — jednostka ognia (szt.) | 320 | 60 | 48 | 34 | 40 | 20 | 30 | 20 | |
| kaemy (szt./kaliber) | — | 1/7,62 | — | — | — | — | — | 1/12,7 | 1/7,62 |
| Ruchliwość: | | | | | | | | | |
| — prędkość maksymalna (km/h) | 42 | 44 | 50 | 48 | 55 | 43 | 37 | 37 | 80 |
| — średni nacisk jedn. (kg/cm²) | 0,54 | 0,57 | 0,70 | 0,80 | 0,68 | 0,85 | 0,81 | 0,85 | |
| — moc jednostkowa (KM/T) | 13,3 | 12,5 | 16,8 | 16,3 | 16,1 | 10,9 | 11,3 | 11,3 | 20,8 |
| — zasięg (km) | 360 | 250 | 300 | 310 | 300 | 150 | 330 | 220 | 600 |
| Pokonywane przeszkody: | | | | | | | | | |
| — wzniesienia | 35° | 30° | 35° | 30° | 30° | 36° | 36° | 36° | 30° |
| — rowy (m) | 1,60 | 2,0 | 2,50 | 2,50 | 2,50 | 2,50 | 2,50 | 2,50 | |
| — ścianki (m) | 0,60 | 0,65 | 0,73 | 0,73 | 0,73 | 0,90 | 1,00 | 1,00 | |
| — brody (m) | 0,36 | 0,90 | 1,30 | 1,30 | 1,30 | 1,30 | 1,30 | 1,30 | 0,50 |
| Silnik: | | | | | | | | | |
| — typ | gaźnik. | gaźnik. | wysokopr. | wysokopr. | wysokopr. | wysokopr. | wysokopr. | wysokopr. | gaźnik. |
| — marka | GAZ-203 | GAZ-203 | W-2-34 | W-2-34M | W-2-34 | W-2-35 | W-2-K | W-2-IS | GAZ M.M |
| — ilość cylindrów (szt.) | 6 | 6 | 12 | 12 | 12 | 12 | 12 | 12 | |
| — moc maksymalna (KM) | 140 ¹⁾ | 140 ¹⁾ | 500 | 520 | 500 | 600 | 520 | 520 | 50 |

¹⁾ 2 silniki o mocy 70 KM każdy.

2.2 THE DIRECTION OF TANK DEVELOPMENT IN THE POLISH ARMY AFTER WORLD WAR II

During World War II the armored forces ultimately advanced to an independent role and became one of the basic parts of the land forces, making up the main striking force of warring armies. The core of the armored forces were the tanks, which, thanks to their great fire power, armored defenses, considerable speed and ability to surmount the obstacles of the terrain, were a threatening weapon in every circumstance of war, both on attack and in defense.

In the first years after the war two factors had decisive influence on the direction of tank development and armored technology:

- nuclear weapons with all the consequences of their use as the chief means of war;
- the further development of anti-armor weapons, in which the effect of accumulated energy was efficiently used.

Nuclear weapons especially dictated that the direction of the development, organization and methods of all types of military operations had to be subjected to revision and adapted to the conditions created by the mass use of nuclear arms. It was not accidental, therefore, that the first post-war period in the construction of tanks possessed an evolutionary character. This was really apparent in all the states which produced tanks. These states in this period fully concentrated on modernizing the tanks they already possessed, mainly by increasing their fire power and mobility. The tense international situation at the beginning of the 1950's, the formation of the North Atlantic Pact (NATO), aimed against the interests of the socialist countries and a series of other

political and economic undertakings by the western powers, leading to the rebirth of German militarism, made the rapid development of the Polish Armed Forces necessary. So, at the beginning of the 6 year economic plan⁽¹⁹⁵⁰⁻¹⁹⁵⁵⁾ the party and government made the decision to accelerate the production of medium tanks in our country. From the point of view of the national economic interests, beginning the construction of a modern armaments industry was a difficult and daring decision. The national economy during the 3 year reconstruction plan (1947-1949) was barely recovered from the wounds suffered during the war.

We undertook the production of the T-34-85 tank with the support of a complex Soviet license, which besides structural documentation and technical conditions also included technological processes and special instrumentation. The aid of Soviet specialists was also obtained in the beginning period of the new production.

The acceleration in the 1950's of the production of military equipment with complex and difficult designs with regard to the technology, and especially the production of tanks, marked a turning point in the post-war development of the Polish machine industry, as well as those industries which worked with it. The level of this accomplishment underlines the fact that Polish industry as a whole did not have great experience in the complicated production of such a complex item as a tank. The incomparable ease and speed in mastering the production of considerably more complex, with regard to design and technology, new types of medium tanks, gained from the experienced obtained from the production of the T-34-85 tank, best testifies to the huge qualitative jump made in all the factories connected to the tank construction program. The T-34-85 tank, produced by Polish industry in the later half of the 1950's, was modernized according to a domestic design-

technological conception. The modernization dealt with the tank's following mechanisms:

- the improvement of the tank engine's ability to start in winter conditions with the use of individual heaters and with a corresponding change in the W-2 engine's configuration;
- a change in the attaching and loading of the machine gun as well as positioning the ammunition in the tank, which allowed the tank crew to be reduced from 5 to 4 persons;
- the adaptation of tanks for the overcoming of deep water obstacles;
- the enlargement of the tank's range.

The modernized T-34-85 tank received the following appellation depending upon subsequent modernizations: T34-85 M1 and T34-85 M2.

Between 1946 and 1955, aided by the experience of building tanks during World War II, numerous models of modern armored equipment adapted to the contemporary conditions of war were designed in the Soviet Union. These designs, thanks to the application of the latest prizes of technology, possessed three harmonized characteristics, decisive for a tank's battle worthiness: fire power, mobility and armored protection. The T-54 and PT-76 must be mentioned in this respect.

At the end of the 1950's, the T-54 became the chief battle vehicle of not only the Soviet Army, but also of all the other armies of the states of the Warsaw Pact. In the construction of the T-54, the best traditions and battle worthiness of Soviet tanks were successfully merged with the most modern, yet simple designs. In comparison with the T-34-85 medium tank, all the principle tactical-technical indicators were improved: fire power, armor thickness and its resistance to projectiles, the engine's power, maneuverability,

range, the reliability of individual mechanisms and the distance covered between repairs.

The development of the T-34-85 tank in Poland allowed a modern production base to be created. Thanks to this, in 1956 the decision was made to produce the T-54 A tank on the basis of a license from the USSR. Together with the beginning of the production of these tanks emerged the necessity of engaging the cooperation of new factories. The share of equipment from various branches of technology was considerably broadened in the construction of the new tank: electronic equipment, electric, hydraulic, optical and many other elements of automated systems.

In the next stages of the T-54 A's production, modernization improvements were designed and introduced into the production process. These included:

- the tank's adaptation to surmounting deep water obstacles;
- an improvement of its firing unit;
- the use of a floor in the rotating turret;
- an improvement of the range;
- the use of a hydraulic system aiding steering by planetary switch mechanisms and a main clutch;
- the use of an air-compressor in the engine's starting system;
- the modernization of the engine's lubrication system.

The appearance of tactical weapons of mass destruction has led to a wide discussion among military specialists on the theme of the characteristics of future military operations, as well as the best corresponding types of tanks adapted to those operations. It was shown that the tank would be the best type of military vehicle for

operations under the conditions of the use of nuclear weapons.

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In the 1960's, the new T-55 tank and its modifications appeared in the Soviet Union. This tank met all the demands of modern warfare. It was intended to be able to fight in terrain contaminated by radioactive radiation, as well as by biological or chemical weapons. Our factories also undertook the production of this tank, based on a license from the Soviet Union.

Independent of the domestic production of the T-55 tank, the further modernization of the T-54 AM tank was begun in the 1960's in order to update its tactical-technical parameters.

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Together with the production of tanks, the designing of special vehicles based on them, intended mainly to be tractors or technical security vehicles, was begun in Poland. One of the first designed was the CZ/T-34/armored tractor, intended for the freeing of bogged down tanks and the assembly-disassembly of damaged T-34 and T-54 tanks. Also based on the T-34 was the CW-34 tractor with hoist, built with the support of documentation from the CSSR. This was to serve for the freeing of all types of bogged down tanks, and the transport of damaged tanks.

At the beginning of 1960's Polish military specialists designed the WPT-34 repair-evacuation tractor, based on the T-34 tank. The introduction of this tractor into armored units did not, however, satisfy the needs of contemporary warfare. Therefore, the WZT-1 technical security vehicle was designed and produced. This vehicle was actually produced and introduced into the military's equipment.

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Another Polish design in the area of technical security vehicles for tank battle operations was the WZT-2 technical security vehicle based on the T-55 tank. This vehicle, with regard to its conception and design, was comparable to the newest vehicles of its class.

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Parallel to the production of tank equipment appeared the need for developing a scientific-research base, which would test and study equipment, both for the needs of the military and of industry, as well as initiate its modernization and follow developments in tank construction throughout the world. In connection to this, in the fall of 1952 the Military Station for the Testing and Research of Motorized Equipment, founded in 1947, was transformed into the Research Testing Grounds for Armored and Motorized Equipment. This military research institution underwent subsequent internal changes, necessitated by broader and more important tasks, and in 1965 the Military Institute for Armored and Vehicular Technology was created on its base.

Throughout its existence, this institute has performed a series of research and experimental-design work connected to tank and vehicular equipment. It is necessary to enumerate the main direction of the Institute's labor and accomplishments:

--the modernization of the T-34-85, T-54A, T-55 tanks and the SKOT and TOPAS armored transports, as well as the design of a prototype for the SG-10 tracked vehicle;

--the improvement (during the developmental process) of Star class vehicles, as well as a series of other specialized vehicles;

--the design of tractors and technical security vehicles (tractors using the chassis of the T-34-85, WZT-1, WPT-SKOT, ^{Moc/Armor}WPT-TOPAS, A/Armor. etc.) and maintenance equipment; --work in the field of ergonomics, consisting of ways to improve the work conditions of the

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vehicles' crews; the hydraulic requirements for a tank's steering, filter-ventilation devices, individual equipment units for the vehicles and their crews;

--the increase in the vehicles' fire power (the increase of unit of fire, equipped in the machine's weapon, etc.);

--the creation of effective means and methods for protecting the armored vehicles from corrosion (corrosion inhibitors, protection methods);

--the increase of the equipment's durability and reliability, as well as the development of means and methods for the securing of battle operations.

At the outset of the production of the T-54 tank, an important and resilient experimental-design subsidiary in industry also was created. Its task was to study, design and construct prototypes in the field of tanks and specialized vehicles using tank chassis, as well as tractors and their modifications.

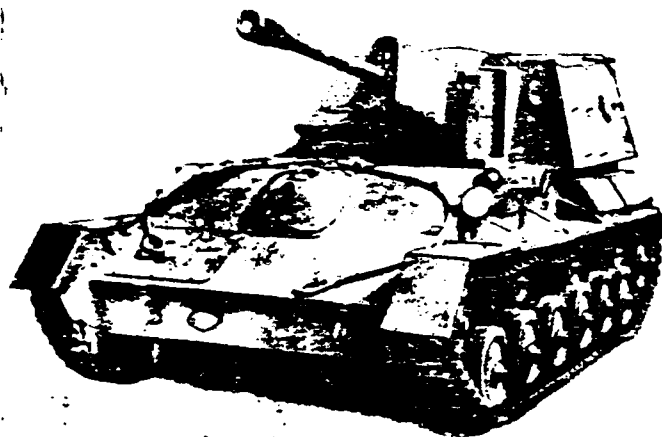
The existing contradictions between high military demands and technical possibilities led to the proposal that in the near future (10-15 years) the classical schema of tank design not be subjected to change. Essential changes in the improvement of tank battle properties, where the present achievements of science and technology have already created the possibility of increasing firing effectiveness and strengthening the armor's resistance while simultaneously reducing the vehicle's total weight and increasing its mobility, however, were expected. The research and experimental labor, performed on a wide scale in recent years, had to lead to qualitative changes in tanks.

The general tendency in the development of tanks in the 1960's and 1970's shows that it is possible to expect in the distant future new designs, which can be quite different from contemporary ones, although, for the next few years the military's basic equipment will consist of that introduced recently to mass production.

| Marka- czalga | Produkcja w latach | | | | |
|------------------|--------------------|------|------|------|------|
| | 1950 | 1955 | 1960 | 1965 | 1970 |
| T-34-85 | — | — | — | — | — |
| T-54 A | — | — | — | — | — |
| T-55 | — | — | — | — | — |

The development of the domestic production of medium tanks.

1. tank model, 2. production in the years.



The SU-76 armored gun

| | Zasadnicze dane | Jednostka | Średnie wartości | |
|-------------|---|--------------------|------------------|------------|
| | | | T-34-85 M | T-54 AM |
| Dane ogólne | CieŜar bojowy | T | 32 | 36 |
| | Załoga | ludzi | 4 | 4 |
| | Moc jednostkowa | KM T | 13,6 | 14,5 |
| | Nacisk jednostkowy | kG/cm ² | 0,83 | 0,81 |
| Uzbrojenie | Działo/kaliber | /mm | armata 85 | armata 100 |
| | Stabilizacja | | — | pion |
| | Kaem pło/kaliber | szt./mm | — | 1 12,7 |
| | Kaem/kaliber | szt./mm | 1/7,62 | 2/7,62 |
| Wymiary | Długość całkowita | mm | 8100 | 9000 |
| | Długość kadłuba | mm | 6100 | 6040 |
| | Szerokość | mm | 3000 | 3270 |
| | Wysokość/z włascem | mm | 2700/ | 2400/2750 |
| | Prześwit | mm | 400 | 425 |
| Ruchliwość | Prędkość max. | km/h | 55 | 50 |
| | Zasięg max. | km | 650* | 830* |
| | Pokonywanie wzniesień | stopnie | 30 | 30 |
| | Pokonywanie rowu | m | 2,5 | 2,7 |
| | Pokonywanie ścianki | m | 0,73 | 0,8 |
| | Pokonywanie brodu | m | 1,3 | 1,4 |
| | Pokonywanie głębokich przeszkód wodnych | m | 5 | 5 |
| | Moc silnika | KM | 500 | 520 |

24 • zmodyfikowane, z dodatkowymi beczkami paliwa.

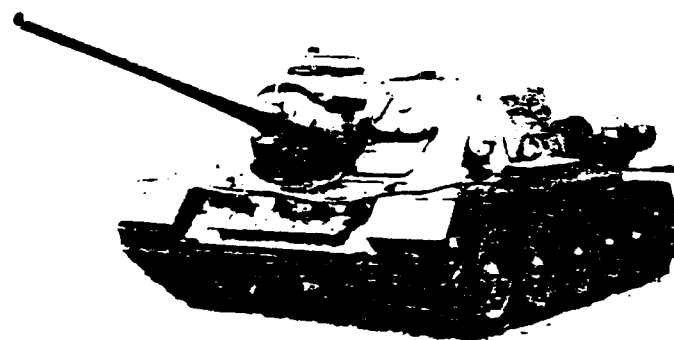
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Table 2.3 A comparison of the tactical-technical data of the T-34-85M and T-54AM tanks

1. basic data, 2. unit, 3. medium tank, 4. firing data, 5. armament, 6. dimensions, 7. mobility, 8. fighting weight, 9. crew, 10. unit power, 11. unit pressure, 12. gun/caliber, 13. stabilization, 14. machine gun anti-aircraft/caliber, 15. machine gun/caliber, 16. total length, 17. body length, 18. width, 19. height/ with machine gun, 20. clearance, 21. max. speed, 22. max. range, 23. slope ability, 24. trench ability, 25. bulkhead ability, 26. wading ability, 27. deep water obstacle ability, 28. engine power, 29. modified with additional fuel tanks, 30. human, 31. cannon, 32. cannon, 33. vertical, 34. round/min, 35. round/min, 36. degree



The SU-85 armored gun



The SU-100 armored gun

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The ISU-122 armored gun



The ISU-152 armored gun

2.3 DIRECTIONS AND TENDENCIES IN THE DEVELOPMENT OF MOTORIZED VEHICLES

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As a result of World War II, the motor vehicle industry in Poland suffered complete devastation. In 1945 there were a total of 14,500 heavy vehicles, personal automobiles and buses in Poland. The situation in the reconstructed Polish Army was rather better due the delivery of a considerable number of motor vehicles from the Soviet Army. The Soviet GAZ-AA-1.5 T and ZIS-5-3 T made up the most numerous groups of heavy road vehicles.

The rapid supplying of the military with various transport equipment in the post-war period required both reliance upon imports and the development of domestic production. In the initial post-war years, as before, the Soviet accelerated its aid to us. Deliveries to the Polish Army were also included in the measures undertaken in the USSR for the production of new types of motor vehicles.

The manifold growth of the number of motor vehicles between 1945 and 1973 testifies to the intensity of this process of equipping our army with various types of transports.

A growth in quality accompanied the growth in numbers, which was obtained thanks to gradual replacement of obsolete vehicles by new ones with better technical parameters. The import of a large number of transport vehicles from the Soviet Union included the following:

- in the group of personal open terrain vehicles, the GAZ-67, GAZ-69 and the GAZ-69A;
- in the group of heavy road vehicles, the GAZ-51 and ZIS 150;

--in the group of open terrain heavy vehicles, the GAZ-63, ZIS 151 and ZIL 157.

The group of open terrain personal vehicles was enlarged with the import of the Robur LO 1800 from the GDR. Also imported were the KRAZ heavy transport from the USSR and the Tatra from Czechoslovakia.

The post-war development of the domestic motor vehicle industry was closely tied with the planned general and dynamic industrialization of Poland. The nascent industry based its production on licensed and domestic designs. The licenses obtained from the USSR in 1951 allowed in the initiation of the production of the Warsaw M-20 motor vehicle and the heavy Lublin 51.

At the base of the production of a domestic motor vehicle lies the decision from 1946, on the basis of which was undertaken the production of heavy 3.5 ton road vehicles, which then most corresponded to the needs of the national economy. From this moment on the tempo of the previously performed work significantly quickened. Simultaneously, the following centers began the design, construction and study of prototypes as well as the work necessary for the preparation and onset of production:

--Department Nr. 3 of the Central Design Bureau in Lodz--for the working out of designs;

--the Testing Section in the Ursus plants--for the construction of prototypes;

--the APMot. Fabrication Bureau in Warsaw--for the working out of the technical documentation;

--the Heavy Motor Vehicle Factory in Starachowice--for the preparation of productive forces.

One effect of this intensified labor was the production of 5 Star-20 vehicles in December 1948, in commemoration of the Congress of the Unification Party.

After the period of mastering production and aspiring to full productive force, in which improvements had a technological character, a basic correction of the Star-20 motor vehicle was considered. As a result of this appeared the Star-21 and then the Star-25, which from the point of view of design was the final stage of improvement and was characterized by far-reaching changes in relation to the Star-20. These changes allowed the vehicle's load to be increased to 4 tons, and improved its ability to travel mountain roads and to tow trailers.

The wide assortment of transport needs required various modifications be made in the vehicles. Therefore, parallel to the development of a series of basic motor vehicles were produced modifications derived from them.

Within the region of native design, domestic industry began in 1968 the production of the Star-28 motor vehicle (with the S-530 A1 air-compression motor) and the Star-29 (with the S-47 A carbureted motor) capable of carrying 5 tons.

The military as the user of a great number of motor vehicles, from the beginning of the motor industry, was vitally interested in its development. The need for the mass equipping of the army with

technical materials demanded the supply of road vehicles, produced by the national economy. This not inconsiderable number of road vehicles could not fully meet the military's need. Therefore, already at the beginning of the development of the motor industry, work aimed at the design of open terrain vehicles was undertaken, on the initiative of the military. The result of this work was the development of the prototypes of the Star-44 and Star-66 medium transports in 1953. The production units of road vehicles were used in their design.

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After studying these prototypes, the decision to discontinue work on the Star-44 was made, because industry, in regard to the insufficient production base, did not think it possible to begin parallel production of two types of open terrain vehicles.

During the period from September 1954 to March 1955, the research performed on the military prototype of the Star-66 made possible the determination of the traction and exploitation properties of these vehicles and of how they could be used by the various branches of the military. The achievements gained, used in this research, placed the Star-66 at the top of this class of vehicles; it succeeded to meet simultaneously the military's traction and tactical requirements.

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After much work and research on increasing the vehicle's durability, the initiation of its mass production ensued. On July 22, 1958, the Heavy Motor Vehicle Factory in Starachovice introduced for delivery to the army the first 25 Star-66's. This event had an unusually far reaching character, since this marked the beginning of the continuous supplying of the army with modern open terrain vehicles of high technical-utilization value. Its traction properties and its

ability to carry 2500 kG ensured that this vehicle, in a very short time, would become the basic means of transport and tow of a great many types of trailers in the Polish Army. This allowed the elimination, or at least a reduction to the absolute minimum, of the import of this category of vehicle. Moreover, thanks to the chassis design, many types of technical security and battle devices could be built on it.

The continuous growing scope of the tasks and uses placed to the Star-66 required the modernization of its equipment, which was performed in two stages. This subsequently led to the Star-660M1 and Star-660M2 vehicles. The entire direction and scope of the modernization applied to the Star-660M1 was aimed at improving its traction and utilization properties. The most important new systems included:

- 12.00--18" tires adapted for work under changing air pressure within the range of .5 to 3.5 atm. and equipped with universal terrain-road sculptured tread (designed at the Stomil Tire Factory in Poznan); the Stomil factory undertook for the first time in Poland the mass production of 13.00--18" tires; it was intended for use with different air pressures;
- the installation for pneumatic blocking of differential mechanisms of the middle and rear drive bridge;
- a ball steering mechanism;
- a universal additional power take-off.

The direction of the second stage of modernization instituted in the Star 660M2 in 1968 aimed at the further increase of utilization and traction properties. The basic scope of the modernization included:

- adapting the vehicle to surmount water obstacles 1.8 m deep;
- the use of an electric installation with three stage screening, making possible the undisturbed operation of radio instruments installed directly on the vehicle or operating not far from them; this

installation was designed to be water resistant, and some of its elements are waterproof;

--a metal load bed;

--modifications of the hand brake, of the valve controlling the trailers' brakes, of the mechanisms assisting the main brakes;

--modifications of the spare wheel's attachment, new gaskets in the drive bridges, modifications of the shape of the motor's casing.

The Star-66, Star-660M1 and Star-660M2 made up the largest group of vehicles used in the army. They were used as transport tractors, the undercarriage of various types of equipment and as special undercarriages.

These vehicle, moreover, were utilized in the national economy in difficult terrain. The Star-660M2 was the last model of the series of production open terrain vehicles.

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In connection with the planned transition to production of the Star-200, a new medium open terrain transport, the Star-266, was designed based on this vehicle, corresponding to the European levels used thanks to the introduction of modern designs in the drive system, suspension, steering system, driver and braking systems. This vehicle was specifically characterized by the ability to surmount the roughest terrain and deep water obstacles. The cabin's design ensures good working conditions for the driver and will protect the crew during operations in contaminated terrain.

The tank-motor vehicle service has endeavored to produce in the near future, not only individual vehicles, but new types composed from

various specialized vehicles, differentiated according to the area of military operations--that is operational-tactical vehicles and battle operations direct security vehicles. These vehicles, consistent with the anticipated properties, are characterized by the wide unification of their systems and even elements. They are also marked by their great mobility and a considerable increase in their load capacity. This has raised the efficiency of their use in battle operations.

Both the domestically produced Jelcz and the imported KrAz and Tatra are found in the group of heavy transports (over 5 tons) used in the Polish Army.

Besides motor vehicles, Polish industry also produces trailers and van-bodies for both military and civilian needs. Already in the 1950's steel-wood bodies were designed for assembly on the chassis of the GAZ-51--type 102 and of the ZIS-150--type 103. Later, the Motor Industry's Design Bureau designed the type 117 van. This was adapted for assembly on the chassis of the Star-66 and Star-660. These types of vehicles with van bodies began a wide assortment of specialized vehicles: workshop vehicles, staff buses, storage battery trucks, fuel trucks, laboratories, etc.

The 250 van, adapted for assembly on the chassis of the Star-660, was designed to better utilize space, for example for health services, staff operations etc. This variant of van in complex, operational conditions, has internal dimensions similar to those of the 117 van, although in stationary conditions, after unloading, it has a closed usable floor space of 25 m². The unloading operation takes 2 persons 10 minutes.

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THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY 30
YEARS OF DEVELOPMENT(U) FOREIGN TECHNOLOGY DIV
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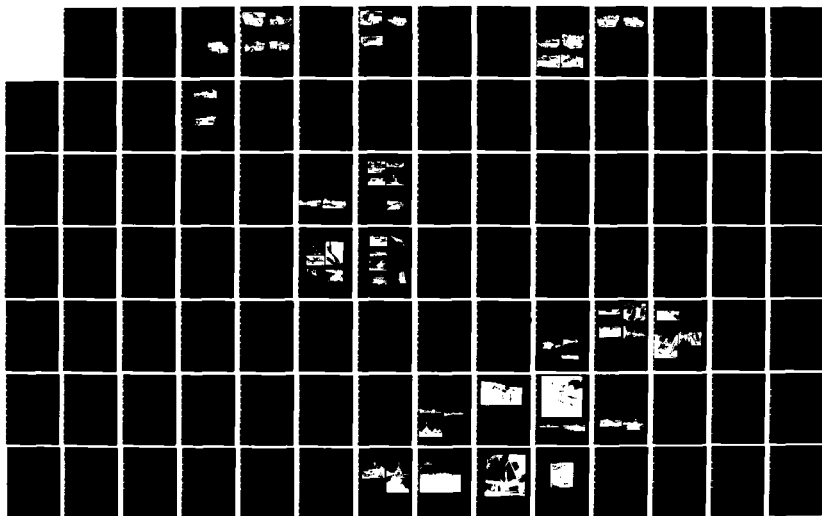
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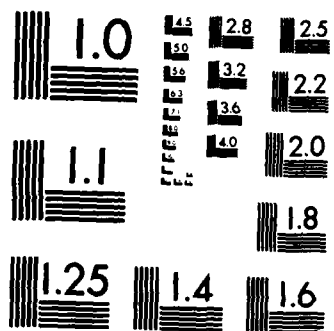
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

There is no way to sufficiently stress the role of the army in the development of the national base, which produces domestically designed vehicles. This is especially true in three basic directions of operations:

--the initiation of research and design work and commission of its industrial realization to design-research bureaus and technical universities;

--the role of military research institutes in a great many qualified, control and military studies, as well as in the direct perfecting of designs;

--the influencing of the technical selection of products for the Polish Army, organized by military representatives on the level and quality of the general production in the motor vehicle industry.

| Czołgi | Działa ² samobieżne | Transportery opancerowane | Samochody pancernie | ⁵ Samochody | Ciągniki gąsienicowe |
|---------|-----------------------------------|------------------------------|------------------------|-------------------------|---------------------------|
| T-70 | SU-57 | MK 1 ¹ | BA-64 | GAZ-11 | Ja-12 |
| T-34-76 | SU-76 | M 17 ¹ | | ZIS-5 | HD-7 ¹ |
| T-34-85 | SU-85 | | | Willys ¹ | ciągniki czołgowe -- na |
| IS-1 | ISU-152 | | | Dodge 3/4 ¹ | podwoziu czołgów średnich |
| IS-2 | | | | Studebaker ¹ | i ciężkich (bez wież) |
| | | | | Ford ¹ | |
| | | | | Chevrolet ¹ | |

¹ 1 Produkcja Stanów Zjednoczonych.
² 2 Produkcja angielska lub kanadyjska.

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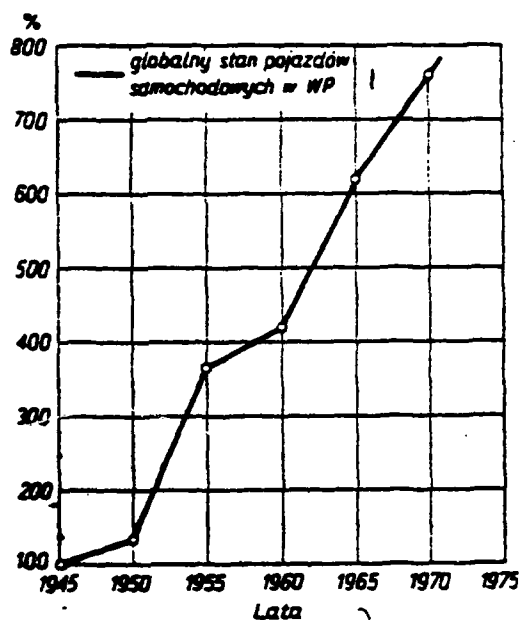
Table 2.4 Specifications for the basic types of armored vehicles, transports and tractors found in the 1st Polish Army
 1. tanks, 2. self-propelled guns, 3. armored transports, 4. armored cars, 5. trucks, 6. tractors, 7. tank tractors--on the chassis of medium and heavy tanks (without turrets), 8. product of the United States, 9. product of England or Canada

| (1) Czołgi | (2) Działa samobieżne | (3) Transportery opancerzone | (4) Samochody pancerne | (5) Samochody | (6) Ciągniki gąsienicowe |
|-----------------|---------------------------|------------------------------|------------------------|--|--|
| T-34-85 IS-2 | ISU-122 SU-85 SU-76 | MR 1 M 17 ² | BA-64 | GAZ-AA ZIS-5 Willys ¹ Dodge 3/4 ² Studebaker ¹ Ford ² Chevrolet ¹ | Ja-12 HD-7 ² Ciągniki czołgowe — na podwoziu czołgów średnich i ciężkich (bez wież) |

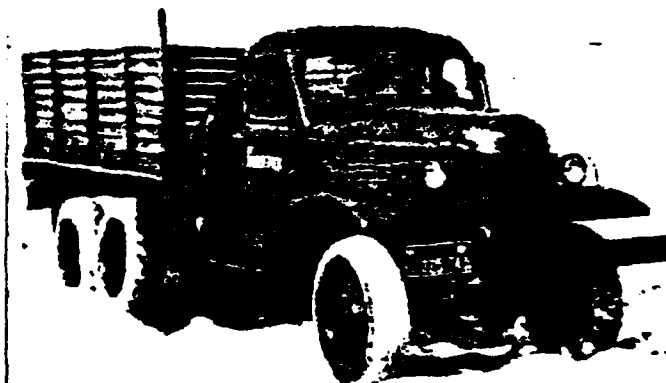
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1 Produkcja Stanów Zjednoczonych.
2 Produkcja angielska lub kanadyjska.

Table 2.5 Specifications for the basic types of armored vehicles, transports and tractors found in the 2nd Polish Army
1. tanks, 2. self-propelled guns, 3. armored transports, 4. armored cars, 5. trucks, 6. tractors, 7. tank tractors--on the chassis of medium and heavy tanks (without turrets), 8. product of the United States, 9. product of England or Canada



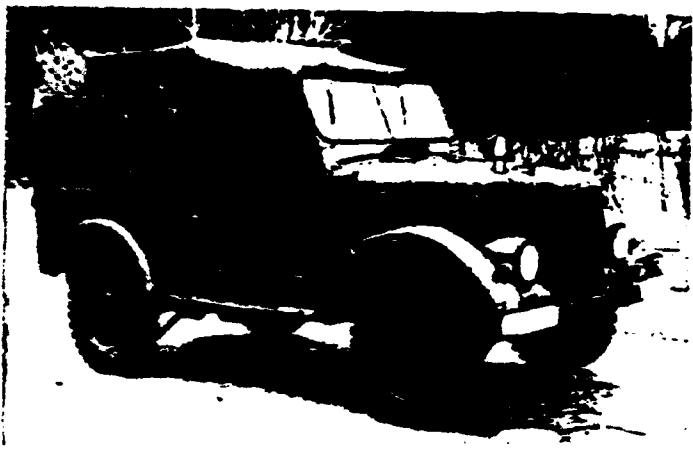
p. 71



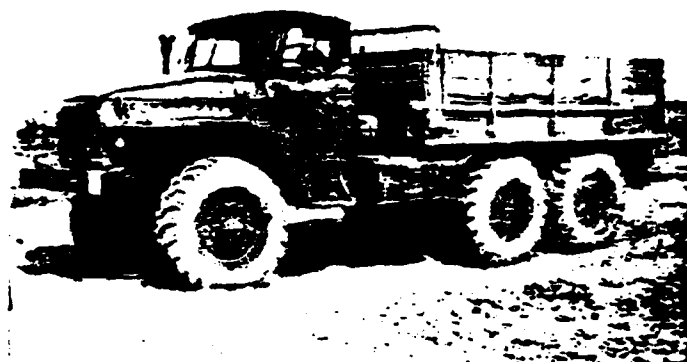
p. 72

The development of motor vehicles in the Polish Army.
1. the total state of motor vehicles in the Polish Army,
2. year

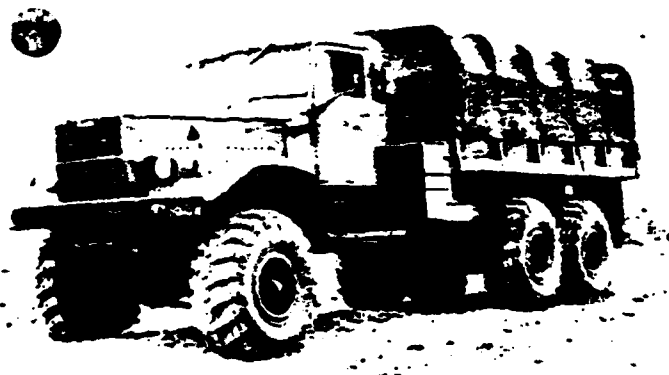
The ZIS 151 truck



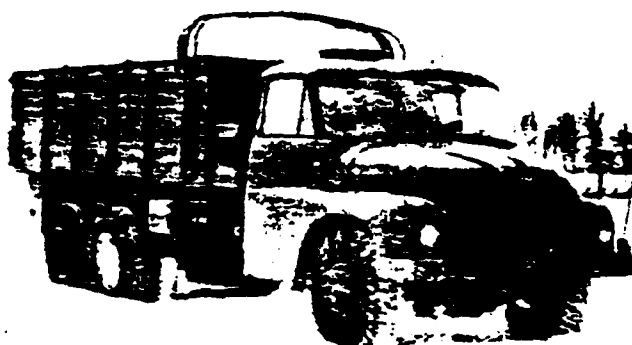
The GAZ 69 truck



The Ural 375 truck



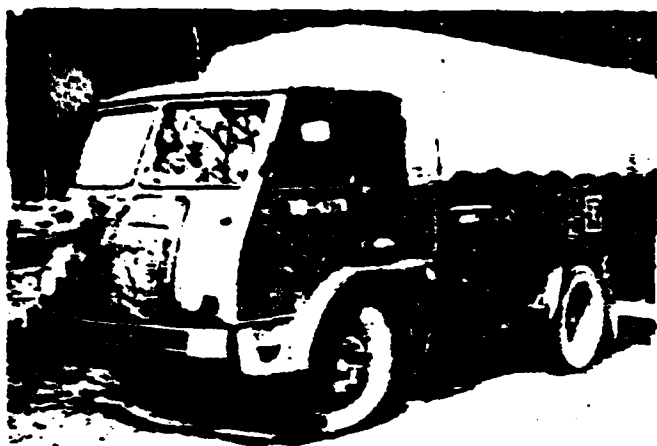
The KrAZ 255 truck



The Tatra 138 truck

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The Star-25 truck



The Star-66 truck



The Jelcz 315 A truck

p. 74-75

Table 2.6 The basic technical data of several trucks introduced into the Polish Army between 1943 and 1973

1. technical data, 2. unit of measure, 3. personal-open terrain, 4 and 5. heavy-road, 6. heavy-open terrain, 7. truck model, 8. initial production year, 9. drive system, 10. load: road, open terrain, 11. number of transport personnel, 12. weight of vehicle ready to drive, 13. trailer towing power: road, open terrain, 14. dimensions: length, width, height, 15. dimensions of the load bed: length, width, height, 16. turning radius, 17. maximum speed, 18. fuel consumption, 19. range, 20. wading depth, 21. clearance, 22. motor type, 23. max. power of motor at n rev/min, 24. hoist towing power, 25. tire dimensions, 26. electric installation voltage, 27 load bed. 28. cabin.

2.4 DIRECTIONS IN THE DEVELOPMENT OF ARMORED TRANSPORTS

The basic stage in the development of armored transports which appeared after the end of the Second World War belongs to the 1950's. The perspective of a war in which weapons of mass destruction could be used and the changes in tactics and the basic performance of battle operations connected with this contributed to the rapid development of this type of battle vehicle. Every modern, mechanized army must have, besides tanks, other types of armored, open terrain vehicles, which can correspond to the rigors of the battlefield. Especially, infantry, cooperating with tanks, must have a mobility consistent with that of tanks and be protected from machine gun fire and fragmentation shells as well as having a strong fire power support.

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The Soviet BTR-152 and BTR-40 transports, with a 6x6 or 4x4 drive system respectively, with which units of the Polish Army were equipped during the first post-war period, did not fully meet the condition of securely transporting infantry on the battlefield. However, the contemporary transport had to be not only a transport medium, as its name would indicate, but also a firing medium. The need existed, therefore, to equip mechanized units of the Polish Army with a new type of vehicle, which met the demands of the contemporary battlefield.

In 1961 an agreement between the governments of Poland and Czechoslovakia was closed concerning the joint production of SKOT transports. The design of this vehicle originated in the design bureaus of the Czechoslovak Peoples' Republic, and from that moment on, Polish specialists from the military and industry were included in design and research work. Preparations for the introduction of mass production proceeded simultaneously in both Poland and Czechoslovakia.

The SKOT transport, produced in 1964, entered into the arsenal of mechanized units of the Polish Army. The transport's modernization was begun at the same time, consisting, on the first level, of weapons. Polish designers, who in a relatively short time proposed weapons improvements on the SKOT transports in order to destroy land based enemy targets, had to solve this task. Recently, Polish military designers have come up with a new type of turret for the SKOT, which allows firing at both land based and airborne targets. The turret's design (with armament) was adapted in Poland to that of the TOPAS tracked armored transport already extant in the arsenal of the Polish Army.

The following makes up the SKOT's basic technical data: the armored vehicle weighs 14,300 kG, it is 7440 cm long, 2500 cm wide, 2060 cm tall without its armament, its motor's power is 180 ^{hp} ~~km~~, its range is 740 km, its unit pressure is 1.15 kG/cm², it has tires with dimensions of 13.00 x 18" with a central pump system, its armaments include 2 connected 14.5 and 7.62 caliber machine guns mounted in a rotating turret, it can surmount various obstacles--slopes up to 35°, 2 m trenches, 2.3 m bulkheads and is amphibious.

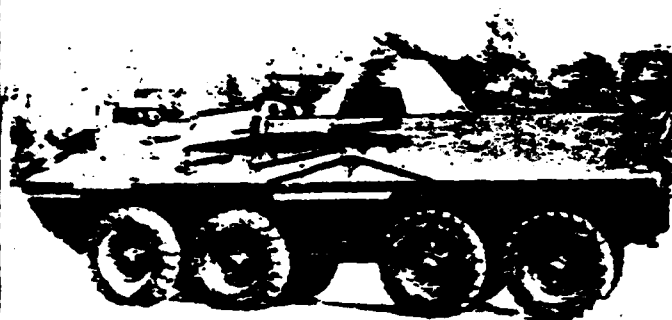
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A series of specialized vehicles have been are being designed on the base of the basic SKOT transport, such as vehicles used for military engineering, communications, artillery, technical preparations etc.

The development of armored transports in recent years has shown that this equipment is undergoing continuous evolutionary modification. The predominate idea behind this modification is the production of a domestic vehicle with various battle and auxiliary functions. Therefore, besides basic armored transports, intended as infantry

battle vehicles for mechanized units, self-propelled guns have been built on their chassis for field and anti-aircraft artillery. Self-propelled tactical and anti-aircraft rocket launchers, as well as technical preparation and ammunition carrier vehicles, have also been built on their chassis.

The continuous improvement of the design of basic armored transports (infantry battle vehicles), as well as the correction of all their basic battle characteristics, has also been observed. These include: fire power, mobility, crew protection and transport landing. It is possible, therefore, to predict that the design of these vehicles will lead in a few years to the production of domestic battle vehicles for land armies.



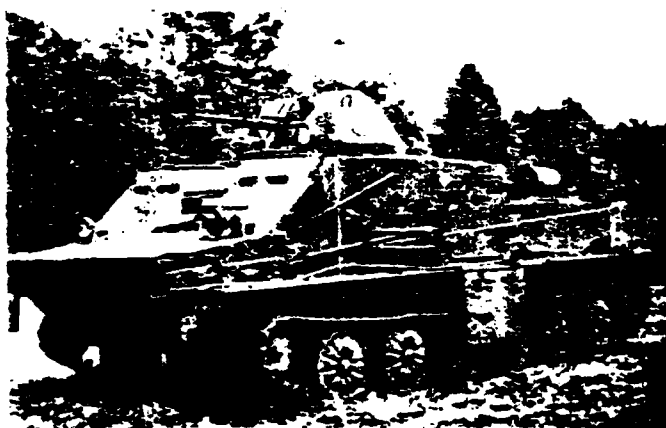
The SKOT 2A armored transport



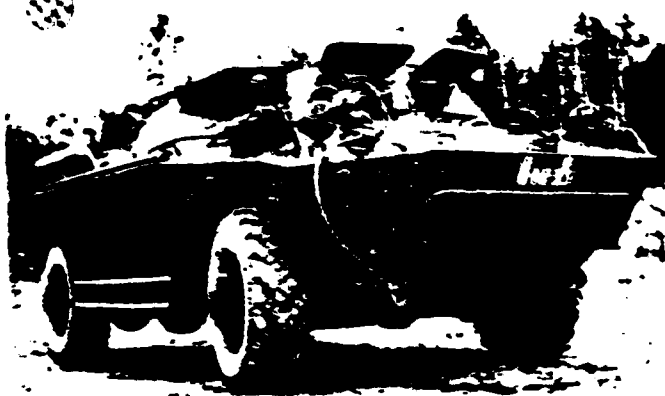
The BTR-152 armored transport



The SKOT armored transport



The TOPAS armored transport



The FUG* armored transport



The BTR-40* armored transport

*in regards to designations, the BTR-40 and FUG vehicles are counted
● the group of reconnoiter armored cars.

Presently, two types of tractors are found in the equipment of the Polish Army: an armored tractor and an artillery tractor. The armored tractor is intended for the evacuation of tanks, while the artillery tractor serves for the towing of artillery and radar equipment. During the war and immediately after it, tank chassis and their turrets were used for armored tractors. The Soviet S-B2 Staliniec agricultural tractor was used for artillery tractors during the post-war period.

The growth of requirements in relation to military equipment, which stem from the development of military thought, also encompasses armored tractors. Work, aiming at the construction of tractors with a high technical-exploitation value, was undertaken. Their construction was based on the undercarriages of contemporary tanks, equipped with additional specialized instrumentation and called technical security vehicles.

In the first stage of the development of artillery tractors, their construction was based on domestically produced tank units. The Mazur D-350 medium artillery tractor was developed in 1962 in this way. In the second stage, production rested upon Soviet license documentation. The production of the new ATS-59 artillery tractor, a much improved version of the D-350, was begun in 1962.

| Zasadnicze dane | Jedn. miary | CZ T-34 Panc. 3 | CW-34 | WPT-34 | WZT-1 | WZT-2 |
|-------------------------------------|----------------|--------------------|--------|--------|--------|--------|
| 1 Ciężar własny | kG | 27 000 | 31 000 | 31 000 | 32 650 | 34 000 |
| 2 Ładowność maksymalna | kG | 3000 | — | 1500 | 3000 | 3000 |
| 3 Ciężar holowanej przyczepy | kG | 36 000 | 36 000 | 36 000 | 36 000 | 36 000 |
| 4 Załoga | ludzi | 2 | 2 | 4 | 3 | 5 |
| 5 Prędkość maksymalna bez przyczepy | km/h | 55 | 55 | 55 | 50 | 50 |
| 6 Moc silnika | KM | 500 | — | 500 | 580 | 580 |
| 7 Nośność dźwigu | kG | 1000 | — | 1000 | 3000 | 10 000 |
| 8 Siła uciagu wyciągarki | kG | — | 30 000 | — | 25 00 | 25 000 |

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Table 2.7 Basic data for tractors and technical security vehicles
1. basic data, 2. unit of measurement, 3. armored, 4. basic weight, 5. maximum load, 6. weight of towed trailer, 7. crew, 8. maximum speed without trailer, 9. motor power, 10. winch carrying capacity, 11. power of hoist's towing power, 12. people

| Zasadnicze dane | Jednostka miary | 473-39 | Mazur D-159 |
|-------------------------------|--------------------|--------|-------------|
| 1 Ciężar własny | kG | 13 000 | 13 500 |
| 2 Ciężar ciągniętej przyczepy | kG | 14 000 | 12 500 |
| 3 Ładowność dopuszczalna | kG | 3000 | 5000 |
| 4 Średni nacisk jednostkowy | kG/cm ² | 0,52 | 0,69 |
| 5 Ilość miejsc siedzących: | | | |
| — w kabinie | ludzi | 2 | 9 |
| — na skrzyni ładunkowej | ludzi | 14 | — |
| 6 Prędkość maksymalna | km/h | 39 | 53 |
| 7 Zasięg | km | 500 | 580 |
| 8 Moc silnika | KM | 300 | 350 |
| 9 Moc jednostkowa | KM/T | 18,7 | 20 |

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Table 2.8 Basic data for tractors

1. basic data, 2. unit of measurement, 3. basic weight, 4. weight of towed trailer, 5. permissible weight, 6. average unit pressure, 7. number of seats, 8. in the cabin, 9. in the load bed, 10. maximum speed, 11. range, 12. motor's power, 13. unit power

3. MILITARY AIRCRAFT

3.1 THE ORIGINS OF THE POLISH AIRFORCE

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A memorable date for the Polish Air Force was June 22, 1943, when in the Soviet Union the first fighter escadrille was organized. This was then followed by the **Warszawa** First Airforce Fighter Regiment. Soon, new units appeared, and the **Krakow** 2nd Regiment of nighttime bombers and the 3rd Shock Regiment were formed.

After finishing training, on August 23, 1944 these units entered into battle action. The main task of our airforce was to support land units. This was the time when the Soviet Army, after sapping the enemy, found itself in a continuous offensive. In these circumstances, our pilots did not encounter significant resistance in the air until the last Berlin offensive. The operations were characterized by endeavoring to provide the maximum support of land forces, reconnoitering and protecting shock aircraft.

Despite its role in the war, the organizational development of the Polish Airforce did not cease in the Soviet Union. In October 1944, the Airforce Command was organized. At the same time the 1st Air Corps was formed with three divisions--bomber, shock and fighter. These units, excepting the bombing division, took part in the war's final phase.

During this period, the Soviet Union provided us with tremendous assistance. As is known, after the October defeat, the majority of

Polish pilots were found in the West. Only a few pilots were in the Soviet Union and consequently the need arose for the training of future pilots. Taking into consideration the fact that pilot training required a relatively long time and special equipment, we must emphasize the great assistance provided by the Soviet Union to our airforce. This assistance did not only take the form of providing aircraft and pilot training, but above all in the relentless work of Soviet instructors.

Besides training planes, the Soviets provided us with Jak-3, Jak-9, Il-2 and Po-2 battle planes.

Operating in the Warsaw region, the Polish Airforce supported the 1st Polish Army at the Warec bridgehead, during the battle for Prague, at Jablonna and during the Warsaw Uprising. At that time, the **Warszawa** 1st fighter regiment and the **Krakow** 2nd nighttime bomber regiment aided the insurgents.

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In January 1945 the great Soviet offensive was begun, which led to the liberation of all of Poland. The Polish People's Airforce carried out at that time a series of successful battle operations. An especially stubborn battle took place in the Kolobrzeg region, where the Polish pilots inflicted heavy casualties on the Germans. Among other things, they destroyed 5 ships, 342 airplanes, 223 wagons and train engines, and 93 cannon.

The crowning battle for the Polish People's Airforce was that of Berlin, in which our airforce flew 2282 sorties, destroying 166 cannon and mortars, 505 airplanes, 20 tanks, 12 automobiles and 75 steam

engines and wagons.

By the war's end the Polish People's Airforce numbered around 550 military aircraft and 16,400 soldiers. It was a considerably larger force than that which comprised the Polish Airforce in August 1939. Moreover, Polish divisions in the West numbered 240 airplanes and around 14,000 soldiers.

The basis of the present airforce became those units and cadres which participated in the trail of battles from Warsaw to Berlin. The youth, prevented by the war from entering the airforce, began to flock to these units after liberation. Also, those who fate cast into the battle for Poland's freedom on the western front, returned to Poland after the war's end.

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After the end of military operations, between 1945 and 1949 began a new era in for the Polish People's Airforce. Above all, shock units received Il-2 airplanes, know from the war, as well as new Il-10 with greater fire power and better tactical characteristics. The bomber units received the improved Soviet Tu-2 instead of the Pe-2. The training of new pilots and the improvement of extant cadres also began at this time. Obviously, there were great difficulties. Devastated landing strips were, for the most part, incapable of use. Hangars, airport buildings and instruments lay in ruins. It was often necessary to rebuild them from scratch. Thanks to tremendous efforts and the assistance of air instructor-command cadres from the Soviet Union, the training of flying and technical personnel was begun. The training of airforce officers for all specialities was begun at the same time at various universities in Poland and the Soviet Union.

The years of 1950-54 marked a turning point in the development of Polish People's Airforce. This period was characterized by an increase in international support, caused by the Korean War and the revisionist actions of the West. All this forced our country to endeavor to increase its defensive potential. An essential element of this effort was the rearmament of our airforce with new equipment and airplanes, and especially with domestically produced jet aircraft. This required a series of undertakings connected with the building and expansion of the Polish aircraft industry and the creation of a corresponding technical and aircraft base.

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Taking into consideration our personnel and economic situation at that time, the realization of a complex program was an accomplishment on a world scale. In order to evaluate our efforts in mastering the technology necessary to produce such complicated equipment as jet airplanes with their motors and accessories, it is necessary to acquaint ourselves with the characteristics of the dynamics of the technical development of aircraft.

| Typ | Rodzaj samolotu | Zaloga | Prędkość (km/h) | Uzbrojenie |
|--------------|-------------------|--------|-----------------|--|
| <i>Jak-1</i> | myśliwski 6 | 1 | 580 | 1 działko, 2 km. |
| <i>Jak-9</i> | myśliwski 116 | 1 | 600 | 1 działko, 1 km. |
| <i>Jak-3</i> | myśliwski 9 | 1 | 720 | 1 działko, 1 km. |
| <i>Il-2</i> | szturmowy 9 | 2 | 400 | 2 działka, 1 km., 400 kg bomb, pociski rakietowe |
| <i>Po-2</i> | bombowy 10 | 3 | 520 | 3 km., 600—1100 kg bomb |
| <i>Po-2</i> | łacz. lekki bomb. | 2 | 140 | 1 km., 200 kg bomb |

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Table 3.1 Airplanes of the Polish Airforce during World War II
1. type, 2. airplane category, 3. crew, 4. speed, 5. armament, 6-8. fighter, 9. storm, 10. bomber, 11. liason, light bomber, 12. gun, 13. gun, 14. gun, 15. 2 guns, 400 kg bombs, rocket shells, 16. bomb, 17. bomb



the Jak-9 airplane of the Warszawa fighter regiment ready for flight
in formation in 1946



the Tu-2 bomber

3.2 CHARACTERISTICS OF THE DYNAMIC DEVELOPMENT OF AIRCRAFT

One of the most important qualities of aircraft in comparison with other forms of transportation is its exceptionally great speed. This is not accidental, because of the character of the milieu in which the airplane operates; its sense of three dimensions and the lack of obstacles, as well as the relatively little resistance create possibilities and conditions unobtainable by either land, sea or submarine vehicles. These possibilities were already perceived during aircraft's first developmental period. However, the systematic domestic utilization of this trump card has arisen only in the last thirty years.

It is not, therefore, strange, that many of the factors influencing the development of most aircraft essentially aspired to the incessant improvement of the aircraft capabilities (great maximum and climbing speed, slow minimum speed, high ceiling and great range, short starting and loading, great load capacity), and in particular--the obtaining of a greater vertical and horizontal speed during flight for military planes. All design, material, production and economic qualities were subordinated to this aspiration. Very fast planes with great climbing speeds were characterized by great maneuverability. Military aircraft also had the potential to overtake enemy aircraft and use predominance over it to obtain a suitable attack position. Airplanes' great speed guarantee the rapid performance of battle missions, which greatly lessen possible interception by enemy aircraft and reduces the effect of the operation of land based anti-aircraft artillery (both conventional and rocket). As has been seen, the increasing of the speed of airplanes has a special significance for military aviation, especially since there exists a wide range of military conditions for the utilization of equipment at

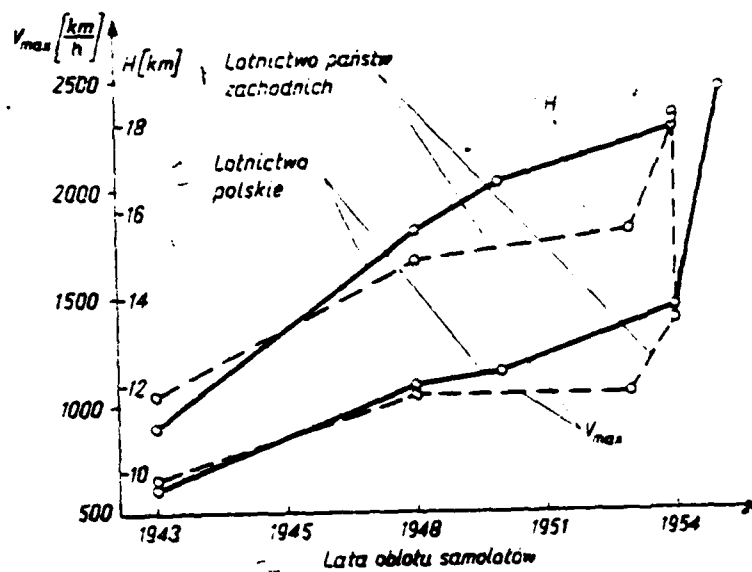
low and high altitudes at slow and fast speeds. It is not, therefore, accidental that the direction and tempo of the development of aviation as a technical field was decided most often by its military use, based on the allocation of huge sums in a determined political situation on the development of the newest or most improved weapons. Hence, the development of civil aviation was always "shifted in phase" in relation to the military, which meant that civilian aircraft was usually designed on the basis of previous experience, and only to a lesser degree, stemming from specific application, had its own aerodynamic-design development.

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New types of propulsion undoubtedly determined the progress made in aircraft in the last thirty years--jet propulsion. The role of other factors contributing to the attainment of greater speeds and altitudes cannot, however, be minimized. Progress in many fields always marked every success. As experience has taught, the improvement of aircraft applied characteristics can be obtained by:

- the use of very economical propulsion systems, either with greater thrust or with fewer or lighter over all dimensions;
- the improvement of the aircraft's aerodynamics in the direction of lessening the resistance in the entire range of speeds used, and aerodynamic heating at maximum speeds;
- the use of durability-design systems securing the fuselage's required durability and rigidity at its minimum weight;
- the technical improvement of the fuselage, propulsion system and equipment by decreasing their weight and complexity;
- the use of lighter and very durable materials (in basic thermo-durability cases);
- new equipment ensuring the aircraft's simpler steering and precise fulfillment of its mission, the improvement of the crew's working conditions during the flight and under conditions of damage;
- the optimal adoption of systems in regard to their technical readiness or cost;
- the use of new, very effective types of weapons, steering and

Change in the speed (V_{max}) and ceiling (H) of some aircraft with piston and jet propulsion of both the Polish and Western airforces
 1. western airforces, 2. the Polish Airforce, 3. the years of the aircrafts' test flights



defense.

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As can be seen from the above, the influence of achievements in the field of propulsion, as well as the theoretical and experimental achievements of aerodynamics and aviation mechanics, aircraft design, material durability, airport design, knowledge of commercial materials and electronic or automatic production equipment all influenced the development of aviation.

The most important characteristic of the transition from subsonic to supersonic aircraft was the rapid growth of undulation resistance and the worsening of the aircraft's stability and steering. As a result of theoretical and experimental research, it was discovered that the most effective means to decrease undulation resistance and diminish the intensity of collar phenomena at the speed of sound was the use of shorter or oblique wings with a thinner relative profile. The use of systems with such shapes in the fuselage allowed the speed of sound to be surpassed relatively easily. If breaking the sound barrier by means of a rapid increase of the engines' draught in aircraft with simple wings of a thick relative profile has caused difficulties, these have been eliminated to a significant degree on aircraft with oblique wings at the speed of sound. The use of triangular wings, which combine the characteristics of being extremely oblique, limited elongation and a relatively thin relative profile, has been shown to be very effective when the recommended level of rigidity has been maintained. Therefore, in the history of the development of jet aircraft, planes were built with wings with much less surface (an increased individual load) and thinner relative profile.

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It is possible to approximate that the majority of these parameters

have reached stable borders, which without radical modifications of the aircraft's shape, cannot be crossed, or whose crossing is from other regards is superfluous (for ex. with regard to the characteristics required for taking off and landing).

The increase of aircraft capabilities and their ability to perform various tasks, both against land based targets and airborne ones, in connection with the arming of airplanes with nuclear weapons, more complex designs and exploitation difficulties, the expansion of ground services, airports and their equipment and the organization of the airforce and its tactics all have led to changes in matters of security and in the operations of airforces. It is evident that the growth of aircraft capabilities is inseparably connected with the cost of their design, production and utilization. It is sufficient to remember that for example, the cost of the first jet fighters was approximately six times more than that of the best propeller aircraft of the Jak 9P class used by the Polish Airforce. The cost of a modern supersonic plane has increased by over thirty fold. When one considers the expense tied to the use and repair of aircraft, the building of new or the modernization of old airports, etc., he will understand that the development of military aircraft, both quantitatively and qualitatively, cannot be considered apart from the national economy and industrial base as well as the national policy in the area.

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3.3 THE ROLE OF THE NATIONAL AVIATION INDUSTRY AND POLISH DESIGN AND RESEARCH THOUGHT IN MEETING THE NEEDS OF THE AIRFORCE

The intense development of aircraft, the systematic growth of its complexity and the differentiation of its assortment, as well as the

increase in cost, has created a situation in which the role of the national aviation industry in meeting the needs of the Polish Airforce has a series of key aspects.

The possession of the corresponding potential of the aviation industry rests to a great degree on the national supply advantageous not only in regard to its increased efficiency, but also to the means remaining to the national economy.

The development of the aviation industry, through aircraft exports, essentially balances the purchase of imported aircraft.

Therefore, the resilient potential of the productive base and scientific-research subsidiary create especially advantageous conditions for uplifting the qualifications of the personnel base of aviation specialists. It becomes the bearer of technological progress in the process of utilizing and repairing aircraft and developing the base for maintenance equipment.

It is not surprising, therefore, that throughout the entire period of rebuilding and developing our socialist economy, the problem of developing the national aviation industry occupied a key place in the interests of the Polish Airforce.

The Polish aviation industry was devastated during World War II. Its greatest loss, however, was the destruction of many highly qualified aviation experts. With other important losses in this period, such as the expenditure of financial means, the Polish aviation industry

fell behind that of other countries, which developed their activity in the period of aviation technological progress during World War II.

In 1944 in response to a general appeal by the Polish National Liberation Committee aviation engineers began to assemble in the liberated area of the country, in order to build a foundation for the aviation industry of the Polish People's Republic. The fact that the first design team assembled under the direction of the engineers, Sutlowski and Soltyk adapted the carpenter workshop in Lodz to the needs of aircraft production, making the same money as producers of furniture for their long hours of aircraft labor, testifies to the great enthusiasm and engagement of the cadres of aviation specialists undertaking this mission, so disproportionate to their power and intentions.

The years from 1945 to 1950 formed a period of the reconstruction of the fundamental elements of the production potential. Unfortunately, it was necessary to start from the design and production ABCs, renovating and rebuilding production objects, the completion of machinery, apparatuses, instruments and training for the relatively simple tasks of technical aviation cadres.

Opened several months after liberation, factories in Mielek and Rzeszowa undertook the repair of engines and airplanes. By the first quarter of 1946 the Mielek factory had stopped the outflow of 3 million zloties, and by the end of 1946, this factory was employing 800 workers. The aviation industry also included a shop in Pes Pol, forming the embryo of a new factory.

In August 1949 the administration of the Ministry of Industry and Trade dispatched the following order to the communal council of Adampol, a village around 9 km from Lublin:

"2 ha of potatoes should be dug up and the forest belonging to the local peasants cleared..."--so originated the communication device plant in Swidnik.

In subsequent years other communication device plants were developed and their appellations: WSK Warszawa-Okecie, WSK Warszawa-Praga, WSK Kalisz and a series of others.

The Aeronautics Institute and the Military Aeronautics Institute were also organized. Later, pilot studies were developed at polytechnical and middle schools, training various flight specialists.

3.4 POLISH AIRCRAFT DESIGN

In April 1945 the Experimental Aeronautical Laboratory (LWD) was opened in Lodz, where on October 28, the first flight took place of a post-war aeronautical design, the Szpak-1 liason-dispositional aircraft

The second Polish aircraft was designed during the course of battle operations, in the fall of 1944 in the Aeronautical Technical School in Zamosc, and later in spring 1945 in the PZL Mielec was designed the training-liason PZL S-1 plane. The test flight of its prototype took place on November 15, 1945.

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In 1946 the Aircraft Study Center was established in Warsaw, which became an important design center (CSS).

In the period between 1945 and 1950, 18 types of aircraft were designed in Poland. These were largely light acrobatic, training-liason, dispositional, sport and training airplanes.

According to the chronological order of the prototypes' test flight, the following appeared:

| | | |
|-----------------------|------------|---------------|
| LWD Szpak-2 | oblatany 2 | 28.10.1945 r. |
| PZL S-1 | " | 15.11.1945 r. |
| LWD Szpak-3 | " | 17.12.1946 r. |
| LWD Zak-1 | " | 23.03.1947 r. |
| LWD Szpak-4A | " | 20.05.1947 r. |
| LWD Zak-2 | " | 27.11.1947 r. |
| LWD Szpak-4T | " | 5.01.1948 r. |
| LWD Junak-1 | " | 22.02.1948 r. |
| LWD Zak-1 | " | 1.09.1948 r. |
| CSS-10A | " | 3.09.1948 r. |
| CSS-11 | " | 16.10.1948 r. |
| LWD Zak-14 | " | 20.10.1948 r. |
| LWD Zak-3 | " | 8.11.1948 r. |
| LWD Zuch-2 | " | 1.04.1949 r. |
| CSS-10C | " | 24.04.1949 r. |
| LWD Junak-2 | " | 12.07.1949 r. |
| Pegaz (motoszybowiec) | " | 16.07.1949 r. |
| LWD Miś | " | 24.11.1949 r. |

1. motor glider, 2. tested

Only the CSS-13 and Junak-2 were mass produced in this period.

The CSS-13 was produced according to the license documentation of the Po-2 airplane, as a training-liason airplane. Between 1948 and 1950, the PZL Mielec factory produced 180 such airplanes. Between 1952 and 1956 this output was delivered to the WSK Oket, where another 380 CSS-13 airplanes were built. These were used as training-liason

airplanes in the military.

The Junak-2 plane was built as a training aircraft. Between 1952 and 1954 the series 150 of this airplane was produced for the training of military pilots.

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The period between 1950 and 1960 was a period when the domestic aviation industry entered into the orbit of the contemporary technological and technical level in the field of modern aeronautic equipment and production methods.

Thanks to the technical, organizational and personnel assistance obtained from the Soviet Union, the production in Poland of the first military jet planes, the Lim-1, Lim-2 and Lim-5, based on the Soviet license, was begun in the first years of the 1950's. These airplanes fully corresponded to the current level of world aeronautical technology.

The first years of the 1950's, therefore, was a turning point in the post-war activity of the Polish aviation industry. The introduction of the production of jet equipment required not only revolutionary modifications in the industry itself, in the sense of having to improve the machinery, but in the introduction of new technological processes, new materials and organizational methods. It was necessary to develop, and sometimes to build from the foundation complimentary industries, for example aluminum works, rollers for aircraft sheet metals, the production of aircraft bearings, radio navigation equipment, aircraft tires, etc.

The concentration of the efforts of cadres of specialists on introducing the production of jet aircraft based on licenses undoubtedly influenced the limiting of domestic designs, especially in the early years of the 1950's.

After 1955, in order to meet the needs arising from the Korean War and a spate of jet aircraft orders, the factories began to develop new types of equipment and began the mass production of series of new types of airplanes and helicopters.

Analyzing the chronology of aircraft designs according to the date of the prototype's test flight, we can see that between 1950 and 1955, 6 new types of aircraft were tested. They are:

| | | | |
|-------------------|---|------------------------------|-----------------|
| BZ-1 <i>Gil</i> | 1 | — pierwszy polski śmigłowiec | — 4.04.1950 r. |
| CSS-12 | 2 | — samolot pasażerski | — 12.11.1950 r. |
| LWD <i>Zuraw</i> | 3 | — samolot łącznikowy | — 16.05.1951 r. |
| S-3 <i>Kania</i> | 4 | — samolot sport. łącznikowy | — 17.05.1951 r. |
| IL <i>Junak-3</i> | 5 | — samolot szkolno-treningowy | — 7.08.1951 r. |
| TS-8 <i>Bies</i> | 6 | — samolot szkolno-treningowy | — 23.07.1955 r. |

1. the first Polish helicopter, 2. passenger plane, 3. liaison plane, 4. sport-liason plane, 5. training plane, 6. training plane

Of the above mentioned types, only two were mass produced, the Junak-3--production begun in 1954 and 100 planes were produced--and the TS-8

Bies--production begun in 1957 and several hundred planes were produced.

Between 1955 and 1960, 10 prototypes were tested:

| | | | |
|----------------|----|------------------------------|-----------------|
| S-4 Kania-2 | 1 | — samolot sportowy | — 9.09.1956 r. |
| PZL-101 Gawron | 2 | — samolot wielozadaniowy | — 14.05.1958 r. |
| PZL-2 Kos | 3 | — samolot szkolno-sportowy | — 21.05.1958 r. |
| M-2 | 4 | — samolot szkolno-treningowy | — 26.06.1958 r. |
| S-4 Kania-3 | 5 | — samolot sportowy | — 10.09.1958 r. |
| BZ-4 Zuk | 6 | — śmigłowiec wielozadaniowy | — 10.02.1959 r. |
| MD-12 | 7 | — samolot pasażerski | — 21.07.1959 r. |
| PZL-102B Kos | 8 | — samolot szkolno-sportowy | — 19.10.1959 r. |
| SM-2 | 9 | — śmigłowiec wielozadaniowy | — 18.11.1959 r. |
| TS-11 Iskra | 10 | — samolot szkolno-treningowy | — 5.02.1960 r. |

1. sport plane, 2. multipurpose plane, 3. training-sport plane, 4. training plane, 5. sport plane, 6. multipurpose helicopter, 7. passenger plane, 8. training-sport plane, 9. multipurpose helicopter, 10. training plane

Of the designs worked out in this period, a rather large percentage of them was introduced into mass production. These are:

the PZL-101 Gawron (a great number were exported);
the TS-11 Iskra and SM-2 helicopter widely used in the airforce.

It is possible, therefore, to accept that the 5 year period of 1955-1960 had to begin the stabilization of the specialization profile of

our aviation industry.

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After the expansion and elevation of the level of the productive base, the development of the Polish aviation industry was directed toward the perspective needs and discernment of the market place in connection with the technical, technological and research possibilities of the national subsidiaries.

The growing number of worked out prototypes, which entered into the production phase, testifies to this activity.

The 1960's for the Polish aviation industry was a period of the further intensification of production specialization, which all the more expressively included:

- multipurpose airplanes with a load capacity of 2000 kg;
- light liaison and multipurpose planes;
- training planes;
- light and medium helicopters;
- gliders and propulsion systems, accessories and special equipment.

The direction of new designs is also an expression of the intensification of specialization. In the 1960's 12 airplane prototypes were tested. Among these were:

- 2--new versions of the Iskra;
- 7--subsequent developmental series of the Wilga;
- 1--training plane designated for the army's M-4 Tarpan;
- 1--photometric version of the MD-12 F airplane;
- 1--agricultural version of the PZL-101 Gawron.

The An-2 multipurpose airplane. The fact that this airplane was exported to many countries, that it broke the world record for the size of the lot production, deserves to be emphasized. The number of this type of airplane produced until today exceeds 5000. This number has not been met in the aviation industries of the countries of Europe, and is rarely encountered anywhere in the world. The possible adaptation of the An-2 for agricultural flights has led to the discovery that 5 of the aircraft adapted for agricultural flights in the world are Polish produced.

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The TS-11 Iskra training airplane has become the basic trainer for airforce pilots; thanks to its utilization value, its flight achievements and characteristics, it is holding its own on the world scale. Its use qualities and successful design have led to the design of a series of versions which are expanding the range of this plane's use, both in training and in its military applications.

The multipurpose PZL-101 Gawron airplane was designed as an adaptation of the Jak-12M improving its load capacity from 350 to 600 kg. Such a solution to the problem of providing a multipurpose airplane was very advantageous from the viewpoint of economy, because it could be quickly and cheaply produced with the relatively large use of the instrumentation which exists for the production of the Jak-12M. Between 1960 and 1970 around 350 Gawron airplanes were produced, and in later years it is still attractive to prospective buyers. The fact that this airplane allows us to export economic services carried out on very good conditions must be emphasized.

The multipurpose PZL-104 Wilga airplane is greatly esteemed for its efficient design. Around 150 have been produced so far. Subsequent

improved versions have been designed. The plane has found a market not only in this country, where it is used by the army and airforce, but also with many foreign users. Indonesia has bought its production license. A large number has been exported to the GDR, Hungary and Rumania. This airplane has even been exported to such countries as Finland, Venezuela, the United Arab Republic and Great Britain.

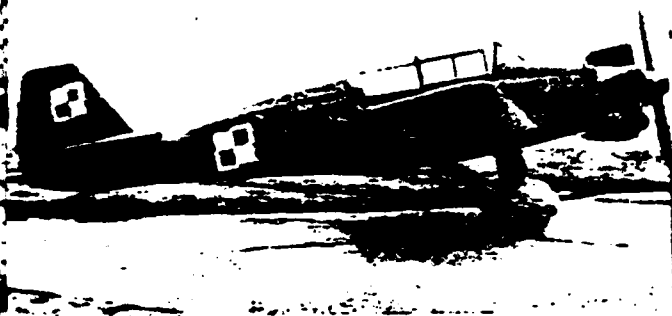
99

The Mi-2 helicopter, which is a version developed from the SM-1 and SM-2 light helicopters, produced in the WSK Swidnik, has been well received in both Poland and abroad. Already several thousand of this helicopter have been produced of which the majority are designated for export.

With regard to the modernity of the design of the Mi-2 helicopter, a special version adapted to use in the army, armed for example with cannon, machine guns and rockets has been designed. Versions adapted for photometry or sea warfare have also been designed.

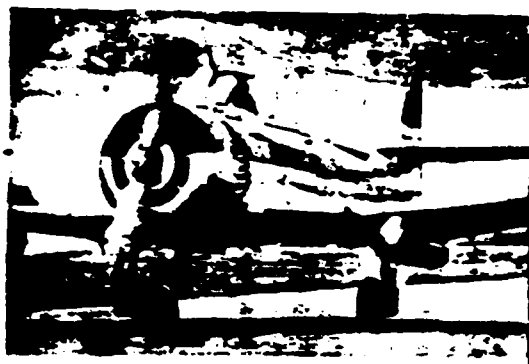
The design of special versions considerably broaden the possibilities of this type of helicopter's use by the armed forces.

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the Junak-2 training plane.

the Junak-3 training plane.



the TS-8 Bies training plane.



the TS-11 Iskra, the first Polish jet training plane.

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the multipurpose PZL-104 Wilga in the version used in the airforce.



the Mi-2 helicopter.

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| 1. | 2. Sample | 3. | 4. Max. altitude (m) | 5. Cruise speed (km/h) | 6. Payload (kg) | 7. Range (km) | 8. Wingspan (m) | 9. Length (m) | 10. Height (m) |
|----|---------------|--------|----------------------|------------------------|-----------------|---------------|-----------------|---------------|----------------|
| 1 | Scout | | 150 | 1200 | 200 | 4500 | 630 | 11,1 | 8,05 |
| 2 | Jonah-3 | | 160 | 1080 | 205 | 4100 | — | 10,0 | 7,75 |
| 3 | TS-8 Bies | | 320 | 1630 | 210 | 6000 | 750 | 10,5 | 8,55 |
| 4 | PZL-104 Wilga | | 280 | 1680 | 170 | 2400 | — | 12,68 | 9,00 |
| 5 | PZL-104 Wilga | | 65 | 370 | 165 | 3200 | 500 | 8,49 | 6,38 |
| 6 | TS-11 Iskra | 880 kg | 5600 | 720 | 11 080 | 900 | 10,06 | 11,15 | 3,30 |
| 7 | PZL-104 Wilga | | 280 | 1150 | 210 | 6700 | — | 11,1 | 8,0 |

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Table 3.2 The basic technical data of some domestically produced airplanes

1. number, 2. airplane, 3. engine power,
4. weight in flight, 5. max. speed,
6. ceiling, 7. range, 8. wingspan,
9. length, 10. height



the Il-28 bomber.

3.5 AIRPLANE ENGINES

The first aircraft engine produced in Poland was the Soviet designed M-11 (licensed). Two versions of it were produced: the M-11D with a power of 140 KM and the M-11 Fr-1 with a power of 160 KM. It was used to propel the popular Po-2.

In the second half of the 1950's a team of engineers from the Aeronautics Institute, under the direction of W. Narkiewicz, designed the WN-3 piston engine, intended to propel the TS-8 Bies training plane.

On the basis of the WN-3 engine was designed its modification, the WN-4, in order to propel the prototype of the BZ-4 helicopter. Moreover, the new WN-6 engine was built with an initial power of 195 KM. It was used in the prototypes of the M-4 Tarpan airplane.

The AI-14R engine was produced to propel our popular Wilga and Gawron airplanes. The building of this engine was begun in Poland in 1956 intended for the Jak-12 airplane. During production many design and technological modifications were made, which contributed to an improvement in the engine's properties. Water injection was used in the suction system to allow for the engine's operation in tropical climates. Moreover, filters were introduced protecting the engine from dust and sand in desert conditions.

The following data can testify to the increase of the AI-14R engine's properties: its initial operating period between repairs was 200

hours; now it has grown to 1000 hours.

The Lit-3 helicopter engine (a licensed Soviet engine) was also produced in Poland.

The ASZ-62IR piston engine with an initial power of 1000 KM has been produced in Poland since 1959 on a Soviet license. Many design and technological changes which have improved its exploitation characteristics and increased its durability were introduced in this engine.

1966 saw the production of the GTD-350 helicopter turbine engine on the basis of a Soviet license. In a modification adapted to the Mi-2 helicopter, the engine's propulsion led out to the rear, with the gas outlet on the left or right. It was also possible to direct the gasses downwards and lead the propulsion out to the front.

The SO-1 jet engine was designed in the Aeronautical Institute and mass produced for the propulsion of the Iskra training plane. The engine consists of the following units and systems: an intake, air compressor, carrying body, turbine, outlet nozzle, gear boxes, lubrication, fuel and electrical systems. The fuel system ensures the engine's proper operation up until the ceiling.

A new version of the engine, called the SO-3, has a modified propeller and drum compressors, as well as a modified way to attach the propeller.

The WK-1A and WK-1F (Lis-5) engines were produced in Poland for licensed military airplanes. The first of these is a jet engine equipped with a single stage centrifugal compressor with a two-sided air intake, 9 combustion chambers, a single stage axial turbine and an unregulated outlet nozzle. The fuel system consisted of two ram pumps, to which a pump supplies the fuel, coming from the fuselage's tanks through a low pressure filter. The pumps have a limited maximum reverse speed. They supply fuel to double channel rotating jet injectors, one in each combustion chamber.

The WK-1F engine differs from the WK-1A by the use of a afterburner (load with dopalanie is 3400 kG and weight 1150 kG).

The evaluation undertaken in the 1970's of the work developed in the Polish aviation industry testifies to the true direction of its development and specialization. Without great effort the conclusion can be drawn that in the 1960's the amount of projects, which could make up the production perspective of the next decade, had expressively decreased.

The consequence of the above tendencies was undoubtedly leading to the liquidation of the Polish aviation industry. The expression of this activity was not only the diminishing number of developmental projects undertaken. The decisive factor concerning the development of the aviation industry was the amount of resources available to it.

Decisive social counteraction supported by the airforce in a key manner checked these tendencies and kept the industry from reaching a

point of no return.

Decisions by the new Party and government leadership, leaning upon a penetrating sounding of the specialist opinion, gave the green light for the activities and development of the Polish aviation industry, as a carrier of technical progress in the national economy, providing a very useful export effect and having a real influence on meeting the needs of the nation's defense.

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As a result of the self-sacrificing activity of aviation specialists in the important effort of rebuilding the national economy, despite key difficulties encountered, the Polish aviation industry at the start of new allied conditions of development possessed an important potential and stabilized position within the national economy.

Such indicators as employment, production space and the value of production qualified the Polish aviation industry to be in the forefront of the European aviation industry.

The effects of production activity verify this position and show that from 1950 until 1970 Polish aviation enterprises produced:

- 11,000 airplanes and helicopters;
- 21,000 aircraft engines;
- 3,000 gliders.

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A dynamic growth in production occurred in this period. The value of the aviation equipment produced between 1966 and 1970 was 6.5 times greater than that of the period between 1950 and 1955.

The supply of our airforce with equipment by the Polish aviation industry also played a key role.

The result of this dynamic production was the aviation industry's rapid advance in becoming one of the largest Polish exporters. The aviation industry is only eclipsed in regard to the dimensions and range of exports by the shipbuilding industry.

The present Polish aviation industry in light of the new direction of the Party and government is at the beginning of another developmental acceleration.

The guiding directions of specialization and development, regarding both the total needs of the national economy and national defense, during the determination of particular priorities for the aviation's industry's development, clearly and openly call for an important examination of its potential and its cadres of specialists and workers.

Table 3.3 Basic technical data for some nationally produced aircraft engines

1. parameter, 2. engine, 3. power, 4. revolution speed (rev./min.), 5. unit fuel consumption (lg/KMh or kg/kGh), 6. diameter, 7. length, 8. weight of dry engine, 9. specification, 10, 12-14, 16-17. airplane, 11, 15. helicopter

| 1 Parameter | 2 Silnik | | | | | | | |
|--|-------------------------------|---------------------------------------|------------------------------|--|-------------------------------|------------------------------|--------------------------------|--------------------------------|
| | M-11 Fr-1 | Lu-3 | WN-3 | AI-14R | AS-62IR | GTD-350 | SO-1 | WK-1A |
| Moc lub ciąg ³ | 140 KM | 430 KM | 283 KM | 220 KM | 820 KM | 320 kG | 888 kG | 2400 kG |
| Prędkość obrotowa (obr./min.) ⁴ | 1760 | 2050 | 2250 | 2050 | 2100 | 40 500 | 15 100 | 11 560 |
| Jednostkowe zużycie paliwa ⁵ (lg/KMh lub kg/kGh) | 0,240 | 0,260 | 0,220 | 0,240 | 0,280 | 0,370 | 1,021 | 1,06 |
| Średnica (mm) ⁶ | 1080 | 1272 | 1106 | 985 | 1380 | 522 - 680 | 707 - 764 | 1273 |
| Długość (mm) ⁷ | 960 | 1512 | 885 | 956 | 1130 | 1350 | 2151 | 2640 |
| Ciężar suchego silnika (kG) ⁸ | 180 | 450 | 255 | 199 | 567 | 135 | 330 | 872 |
| Zastosowanie ⁹ | ¹⁰ samolot Po-2 | śmigł. ¹¹ SM-1, SM-2 | samolot ¹² Bis | samoloty ¹³ Gawron, Wilga | samolot ¹⁴ An-2 | śmigł. ¹⁵ Mi-2 | samolot ¹⁶ Iskra | samolot ¹⁷ Lim-2 |

3.6 THE STATE AND POSSIBILITIES OF POLISH AERONAUTICAL TECHNOLOGY

The state of the Polish economy after the war and the complexity of aeronautical technology meant that in the first decade our aviation industry was not in the position to meet the demands of the military. In this situation foreign aid was indispensable, since only upon it was it possible to base the future of our airforce. In March 1947 our airforce signed an agreement with the USSR. Its effect was the intensification of aid for our airforce. It was at this time that the airplane moved beyond propeller propulsion, whose ultimate possibilities in the area of aerodynamics and propulsion, and hence, also in the area of tactics and technique, had been reached earlier.

The first years of the 1950's were characterized by the intensification of tensions in international relations, which necessitated efforts at preparing the military for the defence of the country. The conception of the development of the airforce rested upon the basis of the Polish-Soviet alliance and stemmed from the correctness of our national position. The Polish airforce did not have strategic aspirations. The only practical necessity was its maintenance on a level allowing it to combat its enemies in the air and to cooperate with its land forces.

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Technical progress was unbelievably rapid, because of which for the maintenance of a high level of military efficiency it was necessary to periodically modernize our aircraft. In this situation only a few states could undertake the construction of new military aircraft without the fear of alienation from other states with greater financial and industrial potential.

The period necessary to design a new fuselage or engine is obviously very long. For example, the realization of a fighter project during World War II required 250,000 engineer hours (that is the labor of 70 engineers for 1.5-2 years). Designing a jet fighter, besides the significant progress of science, required around 5 million engineer hours (that is the labor of 500 engineers for 4-5 or even more years). Moreover, the cost of this labor, research and new designs was unusually high and difficult to determine.

It is also necessary to remember that not every achievement of aeronautical technology is used in the equipment of air units. Moreover, between the completion of a successful new aircraft design and its delivery to units, there is 4 to 8 years, and this period can be even longer for some aircraft. This time is necessary for the construction of prototypes, their testing, the performance and study of series tests, the preparation and development of mass production and their delivery to battle units.

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In this situation, the majority of states, even those possessing a greater cadre and industrial potential than Poland, decided to import or construct aircraft on license. Poland decided to do both. Our fighter and bomber units were equipped with the Jak-17, Jak-23, MiG-15 and MiG-15 bis R-28 jets. Of these designs, the MiG-15 stands out. Thanks to its design and technology, it remained in use for a very long period of time. This airplane possessed small surface oblique wings (35°) with characteristic flow driver, an engine with greater thrust (2270 kG) allowing a maximum speed of 1050 km/h and a ceiling of 15,200 m. For many years the MiG-15 was one of the world's best jet fighters. It was the first from the family of MiG aircraft found in the arsenal of our airforce.

We live in a a very active period for the airforce's development. Equipment rapidly becomes obsolete and it is necessary to modernize it. The fact that in our fighter units since 1945 pilots have changed their aircraft scores of times, attests to this. This process will continue to exist.

Progress in the aviation industry and conclusions drawn from usage (especially in battle conditions) allowed the introduction of modifications into the production of airplanes (aerodynamic and design modifications, changes in the propulsion, equipment and weapon systems). New versions of an airplane arose in this way, equipped with better engines, better and more reliable navigation systems and sights, etc. In his way appeared the MiG-17 with an engine able to provide greater thrust (2700 kG) as well as with an afterburner and oblique wings of the edge of attack equal to 45° thanks to which its maximum speed was increased to 1100 km/h.

The considerable material resources invested in the construction of aircraft factories and the modernization of their equipment led to the maturation of the technical end of the aviation industry in the second half of the 1950's which allowed the undertaking of the licensed production of the Lim-1 (MiG-15), and Lim 2 (MiG-15 bis) and finally the Lim-5 (MiG-17) airplanes. A base was created, therefore, which provided the Polish airforce the systematic supplement of its equipment with the most modern parameters.

The evolution of power and resources meant that in the next period of arming the airforce, operating in the air defence system together with

rockets and artillery, as well as with other branches of the Polish armed forces, would enter the MiG-19 and MiG-21 supersonic airplanes. On the first of these were used larger angle oblique wings--55°-- and two jet turbine engines with afterburner, as well as radio electronic devices allowing the performance of battle missions under every kind of atmospheric conditions. On the second, however, were used triangular wings and an engine facilitating the development of a maximum speed of Mach 2. These airplanes can also attack ground targets and, therefore, were used in the airforce as fighter-shock airplanes.

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Fighter-shock airplanes are intended mainly for attacking targets on the battle field and are adapted in principle to the attack of ground targets with the help of conventional means in normal atmospheric conditions with regard to relatively simple electronical equipment. Some versions of the MiG-17 (Lim-5) belong to this group. Fighter-bombers with greater take off weight, load capacity and ceiling make up another group of this kind. These allow ground targets removed from the battle field to be attacked. Their equipment and weaponry facilitate the attack of ground targets with the aid of conventional means in various atmospheric conditions. They can also attack airborne targets, since they possess universal weapons (cannon, rocket bays, rocket projectiles and bombs). The most modern airplane of this type is the Su-7, which is also in the arsenal of the Polish airforce.

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The equipment our airforce also includes: the An-12 turboprop transport, intended for the transport and drop of soldiers and equipment; the Mi-4 and Mi-8 helicopters--for the transport of sick and wounded personnel, military equipment and other types of cargo. The Mi-8 helicopter can be used in inaccessible areas.

The growth in the cost of designing, producing and purchasing modern airplanes, together with the development of rocket weaponry contributed to the relative decrease in the airforce's numerical state. However, universal growth characterizes transport and training fleets, adapted for attacking ground targets. This initially arose from the need of the armed forces for the mass transport of personnel and weaponry, as well as material-technical supplies. Of course, the need for the normal training of new pilots adequate for securing leadership to the force remained. This was linked to the anticipated rapid tempo of military operations. Polish industry had great experience and achievements in this field. As mentioned above, such aircraft as the Junak, Bies, Iskra and Wilga, and on license--the Jak-12 and SM-1, SM-2 and Mi-2 helicopters were produced for the needs of the airforce.

It can be seen from the evolution of aviation equipment outlined above, that this is an ongoing process. Aeronautical technology in our military is continuously modified. Equipment is constantly being modernized through increased speed, range and ceiling, improved weaponry and security means which operate on the ground. The Polish airforce is prepared for operations in all possible conditions, possessing improved equipment including supersonic airplanes and having at its disposition well equipped airports throughout the country capable of accepting all types of airplanes at every time of the day and in all atmospheric conditions. It also has the important subsidiaries, such as modern industry and specialized technical cadres.

Progress up to now in the world development of air power has been tied

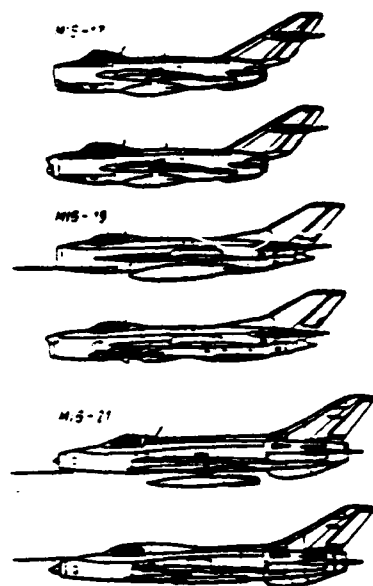
to scientific and technological achievements. Based on the experiences of recent years, it can be suggested that progress will be dependent not only upon the limitations of technology but also upon financial limitations. Therefore, the development of the most advanced airplanes will be considerably curtailed, which will demand the perfection of designs with regard to the reliability and economy of aircraft with performance lessened to a predetermined degree.

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Thanks to the constant growth of the combat possibilities of modern aircraft, the ability of our airforce has increased many times over since the end of the war and has achieved a high level of preparedness, not lagging behind the power of the airforces of the Western European states. The ability of our airforce as earlier grows in proportion to perfection of the technique of piloting and the equipping of units with new radar devices. The effectiveness of air operations also increases as a result of improved cooperation with rocket forces and other branches of the military in attacking targets.

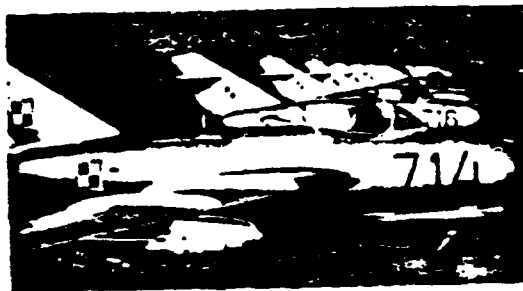
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The rapid development of aeronautical technology, the growth of aircraft achievement found in the arsenal of our airforce and the increase of the military value of aircraft has led to frequent organizational-training modifications, which are perfected by the tremendous efforts of all the personnel, both in the schools and in the units. The Polish Airforce, thanks to the efforts of the entire people under the leadership of the Polish United Workers Party, has been transformed in the last 30 years into an important fighting force, capable of defending the Polish skies whenever necessary. The sense of our power, above all, rests upon a permanent and forceful base, such as Polish-Soviet friendship, the brotherhood of arms with the formidable Soviet Army and with the armies of all people's democracies.



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Types of MiG airplanes, possessed
by the Polish Airforce in the post-
war period



The Lim-2 on the ground

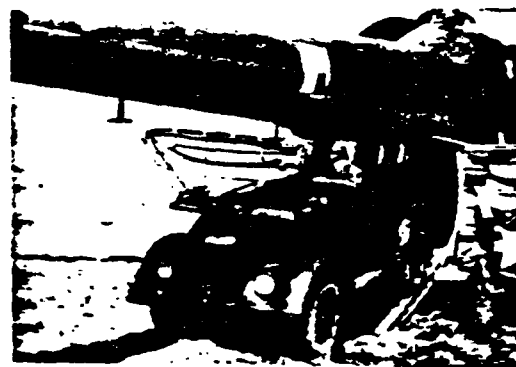


The Lim-5

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The MiG-21 in flight



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The unloading of the Mi-4 helicopter



The MiG-21 landing on a state runway



The Su-7 fighter-shock plane

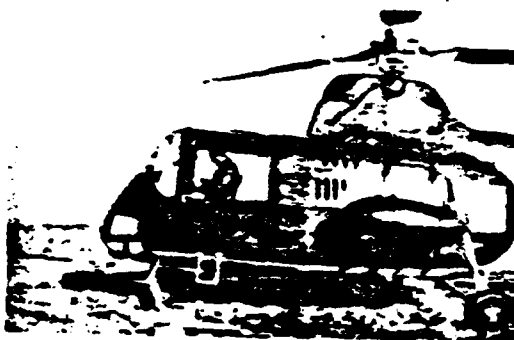


The An-12 transport

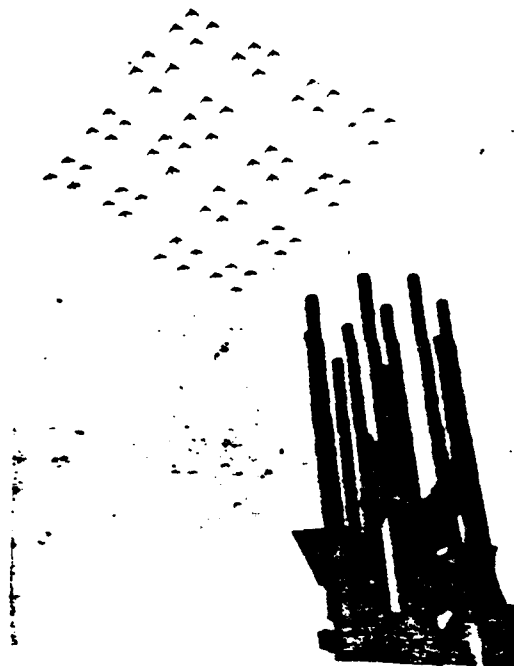
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the SM-1 helicopter



The SM-2 helicopter



An air formation over the
Grunwald memorial

3.7 THE INFLUENCE OF THE TECHNOLOGICAL DEVELOPMENT OF AERONAUTICAL EQUIPMENT UPON THE NATIONAL ECONOMY

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The development of the national aviation industry and the progress of the national economy in many fields verifies in full the thesis that aeronautical technology is not only the stimulus but also the avant garde for progress in many fields of technology and the economy.

For example, the development of aeronautical technology has led to the mastery of production of many high quality steels, light alloys, high quality varnishes, gums and plastics. It has influenced, among others, the raising of the level of production technology in the country's electronic apparatus. The national development of power hydraulics and the improvement of the properties of many products (for example rolling bearings) stemmed from the base of aeronautical technology. Modern designs and numerous technological processes were mastered, such as metal adhesion, the rounding of design elements which increases fatigue durability, etc. It has also had a key influence on the solving of many difficult problems in other branches of the economy.

Such problems include the following:

- using the production experience of the WSK Swidnik with expoxide resins for ventilator propeller blades with greater power for foundries and mines;
- the production in Mielek of railroad wagons for Kasprowy Wierch;
- the production of meteorological rockets for PIHM for the study of the atmosphere's upper layers;
- the utilization of the experience of the WSK Rzeszow in electromagnetic processing and the design and serial production of

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electric drills;

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--the mastering of piston production for piston engines (WSK-Gorzyce);

--the mastering of the production of turboloaders;

--the mastering of the production of brake systems for the Polish Fiat, etc.

Speaking about the aspiration to maximize the achievements of various branches of the national economy, it is necessary to acknowledge as valid the thesis that the airforce utilized the most modern and effective means to achieve this goal.

The practice and experience of our national economy verify the validity of such an assertion. It is possible to cite many examples, from the most important for human life such as the activity of the air force for public health and the navy, to guaranteeing the economy the time and means for activities such as economic services, transportation, agriculture and above all mass communications.

Recently, our airforce, through the use of helicopters, has performed a series of unique operations, completed with full success, connected with construction-assembly work. Thanks to this, it was possible to significantly accelerate production--in several places before the planned end--or to transport objects for utilization. These operations, which we have called--"Gryfia", "Korund", "Malwa" and others, are widely known throughout the country, bringing a multimillion zloty savings for the national economy.

It is also necessary to mention that the airforce, among young people, is a celebrated school for the obtaining of a profession. Soldiers leave the force as qualified drivers, mechanics, communications workers, operators of construction machinery, etc. All of this is of great benefit to our national economy.

4. THE DEVELOPMENT OF THE TECHNOLOGY AND EQUIPMENT OF THE NAVY OF POLISH PEOPLE'S REPUBLIC

4.1 TECHNICAL DEVELOPMENT IN THE NAVY OF THE POLISH PEOPLE'S REPUBLIC

The navy is the part of the armed forces designated for the defense of the interests of the state on the seas. The role of the navy depends in the first part on the characteristics of state politics and the country's geographical position and then--on the existing system of the armed forces and the importance of the naval theater of operations in the total strategical conception.

Before the cessation of World War II, Poland began for the second time in a quarter century to build its naval forces. The fundamentals upon which the navy of the Polish People's Republic was based were essentially different from those upon which was based the navy of the Polish Republic a half century before. The goal of the later was the realization of the power-grabbing plans of the Polish bourgeoisie, while the mission of the former is the defense of the broad, 500 kilometer coast line with large ports and well developed shipping (606 ships with a total tonnage of 1,800,000 tons DWT). The later was the advocate of an aggressive doctrine of an ocean going fleet, while the former is directed by a defensive doctrine and only the defense of one's sovereignty, but also of the bulk of political and social achievements. And so when the later, insulated from political realities by the theory of two enemies, had to construct its own heroic naval epos on foreign waters among foreigners, often inimical to our own interests, the people's navy is a member of the powerful defensive forces of the socialist states, guarding its own borders in service to

its own part of the Baltic Sea shoulder to shoulder with the Baltic Fleet of the Soviet Union and the People's Navy of the GDR.

Beginning in 1945, the development of the navy has proceeded without stop, since the intensification of defensive naval forces is the long-term, calculated and complex mission to develop plans which aim at adapting the present state of development to prognoses of the political and economic situation, plans in which the development of technology and the realization of scientific and technical achievements occupy an important position as well as introducing these achievements into use in the naval defense.

In the middle of 1944 the Soviet Army and the First Polish Army began the liberation of Polish territory. The High Command of the Polish Army began the formation of the Second Polish Army and a series of units of different weaponry and services. The formation of the First Independent Reserve Naval Battalion was begun in this period, based on an order of the High Command on 28 October, 1944. Soldiers, who had served in the navy or the merchant fleet and were found in the ranks of the Polish Army as well as the many Poles who were serving in the Soviet Navy, were directed to this battalion. Volunteers, wishing to serve in the navy were also allowed into the battalion. The shortage of cadres and specialists was tremendous, because the majority of sailors were fighting in the West or were in German prisoner of war camps, and there was really no one from the personnel of the earlier Pinski flotilla because the battalion created from it in 1939 had taken part in the battles of the independent operational group, "Polesa" and together with General Kleeberg, found itself in German captivity. The battalion's movements during the war led it through Warsaw, Kutno, Wloclawek, Torun and Tczew up to Gdansk, where it reached on April 3, 1945. Two days later, part of the naval battalion

took part in the storming of the Westerplatte, but the Germans capitulated earlier without a fight. Part of the battalion defended the port of Gdansk, the shipyards, and its main force was located in Nowy Port. The battalion numbered over 2000 people, forming the basic unit of the Polish Navy, formed on July 7, 1945, by order of the High Command of the Polish Army. The Naval Command began, from its first days of operations, carrying out the undertakings connected with the organization of the defense of the Polish water borders.

The development of the Navy as well as the development of its equipment can be divided into four stages. The first stage, encompassing the years between 1945 and 1950, dealt with the main material and technical reconstruction and organizational bases. The second stage, from 1951 to 1956, was a period of the qualitative and quantitative growth of forces and military capability. The third stage, from 1957-1960, is characterized by the problems of modernization and qualitative technical changes. The fourth stage is characterized by the complex development of our naval forces, by rapid technical progress and undertakings whose goal was the optimal coordination of naval units with other military branches.

The main organizational task in the first stage was the achievement of a determined level of technical and training possibilities, as well as the gaining of a solid battle preparedness on water, which could be achieved only by the equipping of the Navy with ships. It was not possible to count the purchase of ships in this because of the shortage of money in the country exhausted by the occupation. Nor could we hope to build ships in Poland, because industry lay in ruins. The only path to the realization of this task was to obtain part of the pre-war fleet--those ships, which were found in England, interned in Sweden or rescued after the September campaign and found in German hands. At the same time there existed the real possibility of

receiving ships from the Soviet Union, as payment for part of Poland's share of German military indemnities.

Thanks to the efficient operation of the Polish revindication mission in Sweden, ships interned in Swedish ports in 1939 returned the earliest to Poland. On October 24, 1945, the submarines, Sep, Rys and Zbik, the torpedo boat, Batory and the training frigate of the Polish merchant marine, Dar Pomorza, entered the military port of Oksywie. That marked the formation of the submarine division, but units damaged by six years of inactivity required capital repairs, which the Gdansk shipyards undertook. In the course of the repairs, for the first time in the history of Polish industry, periscopes were replaced and new batteries were constructed for submarines, which the factory in Piastowa perfected. Naval cannon were replaced and torpedo apparatuses were adapted for the use of modern torpedoes.

At the end of 1945, the Polish Military Mission in Germany found 4 sweepers, which the German navy had used. The ships, standing in Trawemuende, were completely devastated and their mechanisms were totally damaged. After the completion of the difficult repairs in Kilonia, the ORP Czajka, Mewa, Zuraw and Rybitwa entered into the military port of Oksywie on March 12, 1946. These were expected to constitute the sweeper division for the newly formed Szczecin Region Fleet, but they entered into the line only in the second half of 1947 after more repairs in the Gdansk shipyard. Together with these sweepers was delivered to the flotilla the revindicated heavy river cutter, the Okon, from the pre-war Pinski flotilla. In 1953, the Okon was sent to the Szczecin division of the Coast Guard. Revindicated ships, which spent a long time in repairs because of their poor technical state, did not represent a concrete military force. For example, the Sep entered into the line in October 1947, but was not in

the best of technical shape, while the Rys did not join the line until the end of the next year and the Zbik, until several months after the Rys.

The key turning point in the technical equipment and military force was the obtaining of 23 ships from the Soviet Union, including 9 sweepers, which could lay a mine barrier in the Polish zone of responsibility for the security of the sea. The official delivery of the ships took place on April 5, 1946 in the military port of Oksywie. Besides the mentioned 9 sweepers, the flag was raised over 12 submarines and 2 torpedo boats. This system was composed of modern types of small ships, constructed in 1945 for the needs of closed seas.

In November 1946, the Naval Dry Dock finished the adaptation of 4 German landing boats into fast sweepers, which were included in the Szczecin flotilla. So, at the end of 1946 two naval bases were formed at Oksywie and Swinoujscie, securing the basic technical needs of the navy as a whole and 30 ships, which the fleet had at its disposition at the end of 1946. At the same time, a coast guard was created on both land and in the air. Its basis was a network of observation and communication points and coastal artillery. Organizational-technical preparations for the creation of a naval airforce was also begun. It is necessary to stress that a considerable shortage of naval crews and specialist officers existed in this period and therefore, the organization of naval training institutions at various levels was begun.

An equally important factor was the return of the Polish ships, which had fought on the side of the Western Allies. After long negotiations with the British government, the Blyskawica returned to Poland,

arriving in Gdansk harbor July 4, 1947. With it returned from emigration a group of experienced officers and sailors, the majority of whom entered the ranks of the People's Navy. Because of its condition, the Blyskawica only entered into the line in April 1950, after a year and a half of repair at the Gdansk Shipyard. On July 1, 1948, the training vessel, the Iskra, put in to Oksywie, after having spent the war years as a base ship for submarines off Gibraltar.

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In England remained a destroyer, the Burza, and a submarine, the Wilk, which, because of their poor technical condition, the Polish naval mission in 1947 proposed to exchange for the escort destroyers, the GRP Slazak and Krakowiak. These boats had fought under the Polish flag, providing, therefore, the basic right to their use. Unfortunately, the British government rejected this proposition. The seriously damaged Burza returned to Poland only in 1952. The Wilk also returned at the same time, having to be towed to the port of Gdynia; the ship was, however, so damaged that it was unrepairable.

At the end of the period under discussion, the Polish Navy had in its possession various classes of vessels, from new and used destroyers to torpedo boats, totalling 35, which, therefore, had to be treated as a considerable success in the effort to construct a navy. Coastal divisions played an undeniable role in this period in the development of the equipment of the Polish Navy. So did technical-equipment services and engineer units, which besides responsibility for mine-sweeping operations along the coast, constructed naval bases, built defensive devices, buildings, magazines and barracks. All of this testifies to the immense work carried out in rebuilding the country. Thanks to great efforts, the fleet subsequently obtained three additional sweepers, raising the flag over the ORP Delfin, Mors and Foka on April 19, 1948. These new ships were equipped with

acoustical, electromagnetic and classical sweeping gear.

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The OS Zetempowiec, a training vessel, which saw the raising of the naval ensign on July 10, 1951, rounded off the fleet at the end of this period. This unit was rebuilt from the merchant ship, the MS Opole, which we obtained within the framework of war reparations from the German merchant fleet, where it sailed as the Irene Oldendorff. This ship was renamed the ORP Gryf on April 10, 1957, commemorating the heroic old mine layer, destroyed in the campaign of September 1939. The capital repair of the ship's equipment and its rebuilding was carried out by the Gdansk Shipyard, now called the Paris Commune Shipyard. It must be acknowledged that cadets from the technical section of the Naval Officer's School played a role in the repair work, which was one of their first practical shipbuilding experiences.

Hence, this first period of the fleet's formation was devoted to attempting to secure vessels, and subsequently in repairing usable units and preparing the foundations for the future technical development of the Polish Navy.

The second stage in the development of the Polish Navy took place during a period of sharpening international tensions and the escalation of the "cold war"--the formation of NATO, the rearming of West Germany and American aggression in Korea. This forced the socialist states, including Poland, to intensify their defensive efforts.

Between 1945 and 1955 the Soviet Union delivered to the Polish Navy small type M submarines, built in Soviet shipyards in the 1950's.

These were modern vessels capable of totally meeting operational needs in the Baltic. At the end of this period, the submarine system constituted a force capable of performing the important missions given it, especially since submarines in this period had begun to emerge as the key offensive force in the entire fleet.

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The first deliveries to the fleet of motor torpedo boats produced in the Soviet Union in the 1950's, popularly called "deesams", occurred in this period. These contributed to a significant improvement in the technical condition of the battle force of our surface vessels. At this time, the national industry had also undertaken tests of smaller vessels of all types including sweepers--the most important ships for the sweeping of various types of time activated mines lying in the Polish navigational security zone. The TR-41 through the TR-47, regular sweepers built between 1954 and 1955, performed sweeping operations around the Gulf of Pomerania. These ships possessed the following characteristics: displacement 49 tons, dimensions 27.7 x 4.1 x 0.6 m; armament--one 25 mm cannon, one 14.5 mm double barrel machine gun and the ability of retrieving the sweeping equipment in 25 min. A double shaft power plant with two Polish built 12 cylinder Wola 300 engines, with 300 KM of power each, constructed on a license of the Soviet 3 D12, ensured a maximum speed of 15 knots. A fuel reserve of 2800 kG ensured a range of 500 sea miles at a speed of 10 knots, while food and water reserves allowed 10 days of autonomous sailing for a crew of 16.

In connection with the further development of operational-tactical naval thought existed the need for the formation of forces designated for coastal navigation warfare against the enemy and the naval contravention of enemy landing formations. This task was to be undertaken by attack teams of torpedo boats, which the Soviets,

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beginning in 1954, supplied us in relatively large quantities. These were a newly produced and modern type of craft with two torpedo launchers. The further development and equipping of Polish coastal technical centers continued, and played a large role as auxiliary units. For example, the Kablowiec was rebuilt in the later half of the 1950's from a cargo ship in the Naval Shipyard. The training of leading officer cadres was also begun at all military-naval institutions in the USSR, independently of the training of officers by the Naval Academy, which was founded by a governmental resolution in 1946.

The third stage of the complex development of the Polish Navy was the subsequent important doctrinal and scientific-technical development of the armed forces of the Polish People's Republic, stimulated by the signing of the Warsaw Pact in May 1955--the defensive organization of the European socialist states. Based on scientific foundations, the proportion of individual classes of vessels and the need for the introduction of new types of ships were determined. A special need was shown to be the further development of light shock forces. The older types of vessels found in fleet had become tactically obsolete. Stock was then taken of the condition of the Polish Navy. The fleet of ships was supplemented with new types of vessels of Soviet design, of which it should be mentioned the new craft which received the praiseworthy name of the ORP Orzel. The other submarine remaining from the September campaign, the Sep, whose capital repair was performed by the Naval Shipyard, was also seaworthy. The destroyer fleet also significantly increased its power when two such ships were delivered by the Soviet Union. The ORP Grom was commissioned into the Polish Navy on December 15, 1957, while the ORP Wicher was commissioned on June 28, 1958, the day honoring the Polish Navy. These ships were given the names of heroic destroyers--the Grom, which sank on May 4, 1940 near Narvik in defense of Norway, and the Wichra,

which sank September 3, 1939, in defense of Hel. The other destroyer from the pre-war fleet, the ORP Blyskawica, was completely modernized in 1958 in the Paris Commune Shipyard in Gdynia and again entered into the line in June 1961 as the flag ship. The destroyer, the Burza, reconstructed between 1952 and 1955 for anti-aircraft defense, became part of the fleet, and in recognition of its own battle service--as the oldest of the existing war ships, was transformed into a naval museum in 1960.

During this entire period base sweepers were added to the navy, built in Poland, according to documentation, worked out by the National Design Bureau on the basis of a Soviet license. After the construction of a short prototype series a series of units with more powerful engines and an adjustable drive screw propeller was built. Some Soviet built sweepers, popularly called "catchers", still remained in the line. They were modernized in the Naval Shipyard. During this period, the shipyard also mastered the repair technology of the M-50 high-speed engine, essential for capital inclusion, which in our country, where units of this class were not built, this was necessary for greater success. This enterprise guaranteed the repair of all types of ships and auxiliary units. A characteristic example is the reconstruction in 1951 of the sweeper, the ORP Zuraw (which was built in 1938-1939), into the hydrographic vessel, the Kompas. Its further complex modernization in 1959-1963, included a complete change of its silhouette. The shipyard entered into a phase of rapid development at this time; it reached its planned technical level and alteration power, allowing the undertaking of the construction of modern war ships. By order of the Ministry of national Defense, the Naval Shipyard was renamed Dabrowszczakow Shipyard on October 10, 1966.

The complex rearmament of the navy with new equipment, including a naval airforce with the newest types of airplanes, a wealth of coastal and anti-invasion defenses, the qualitative and quantitative development of the fleet and the formation of a program for technical improvements, became a fact. The solution of the difficult and costly problem of how to secure a high technical-military standard was made possible, above all, by Poland's membership in the Warsaw Pact and the development of the national naval industry.

The fourth stage, begun in 1960, encompassed a period characterized by a series of unusually essential changes, which influenced the dynamic development of equipment and armament. A prerequisite for rapid technical progress was the modernization of organizational structures, the introduction of automated command and management, and the automation of technical resources and ships. The navy had access at this time to an adequate scientific-research and didactic base. The young officers and cadets of the Heroes of the Westerplatte [Bohateri Westerplatte] Naval High School must be cited as one of the main promulgators of modern naval and technical thought among the up-and-coming generation. This school, in its Command Division, taught officers about command directions and military engineers about the use of ships, while the Technical Division taught master engineers and technical specialists the exploitation of ships in specialities: mechanical, electromechanical and electrical. Doctorates, masters and a wide series of other post-graduate programs were offered. Also, we often drew from cooperation with the fraternal fleets of the USSR and GDR, since we used similar equipment, armaments and vessels. Carefully organized exchanges of experiences permitted the development of achieved technical progress, in which the Polish naval industry occupied first place. Thanks to the efforts of our design bureaus and shipyards many types of ships of Polish design intended both for the Polish and Soviet navies were built in Poland.

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It is necessary to mention the new patrol torpedo and anti-submarine boats, developed as the third post-war generation of ships, as being the first rank of the group of domestic designs introduced into the line. These were more automated units, equipped with universal artillery, automatically directed. They had developed submarine detection and warfare devices. They possessed great speed thanks to the installation of more powerful engines, remote controlled from a mobile-maneuver center.

Starting in the 1960's a series of modern Polish produced base sweepers and small and fast landing craft, the smallest units of the navy, was introduced into the line.

But the greatest glory for our industry and creative, technical thought in the field of naval construction falls to landing craft, which are among the best in the world in their class. Armed with modern weapons, rockets, they can guarantee every landing operation.

Recently, domestic industry has delivered a new torpedo cruiser. This unit possesses a rare quality--even among the most modern types of cruisers--speed. The design and production of this unit of high tactical value was possible thanks to our industry's mastery of gas turbines and construction technology for ship hulls from corrosion resistant aluminum alloys. Developmental research in several directions basic for defense and essential for the Polish Navy, was carried out at the Naval High School, whose many scientific workers received in 1972 the cooperative award of the Ministry of National Defense for work contributing in a good part to the creation of the new

technical-military aspect of tactical units and vessels.

The national industry also produced several types of auxiliary units, including hydrographic vessels intended for peacetime oceanographic research. The leading achievement in this field and on a world class is the Kopernik, a naval hydrographic craft. Designed by a special design bureau, it was produced in a Polish shipyard. The Polish ensign was raised over it on February 20, 1971.

Tens of units of this type were built for other countries. At the beginning of this period, our navy obtained from the Soviet Union small four rocket launcher ships. This occurred at a time when the NATO states still did not possess such units. Also, coastal units of the navy were equipped with rocket artillery made up of various types of shells designated for hitting sea, air and land targets. Some rocket artillery units were presented to Polish society for the first time at the Warsaw parade honoring the twentieth anniversary of the Polish People's Republic.

The naval airforce was developed considerably at this time, equipped accordingly with the newest types of supersonic jets and various types of helicopters. It is capable of independent action or cooperation with various classes of ships: to fight sea, air and land targets; to fly reconnoitering missions, to perform rescue actions (mainly for helicopters), which have an important humanitarian and economic significance in peacetime; to fulfill communication and transportation services. The airforce's mission as a partner of naval vessels is the destruction of the enemy's forces, and in particular its surface vessels and submarines, which can fight with rockets and surface weapons, torpedoes and bombs. The missions of the naval

airforce can be divided into: 1) fighter-storming, 2) the attacking of surface vessels, 3) reconnoitering, 4) rescue. Comprehensively trained and equipped with modern equipment, the naval airforce comprises an important fire power with an essential specialist character, which is the mark of only well organized naval forces.

The concept of this developmental path and the achievement of the present state of battle worthiness and technical level, which the navy of the Polish People's Republic represents at the 30th anniversary of the Polish Armed Forces, was possible thanks to the implementation of the policies of national defense, defined by the Polish Workers' Party and the Polish United Workers' Party. The gigantic effort of the entire people gathered around the party's policies created the material base for this achievement. And the technical, specialist and organizational aid of the Soviet navy, which befriended us from the first days of the existence of the People's Navy, made possible the realization of the defensive mission of the Polish Navy on the sea, at a time which was dictated by the needs of the international situation.



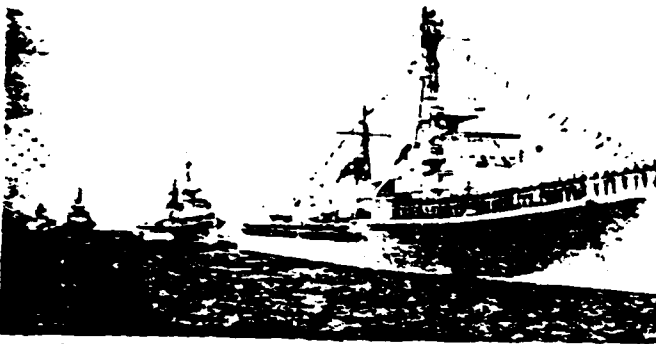
The ORP Burza approaches Gdynia;
since 1960, it has been a naval museum



The Sep, a submarine, as it looked
in the 1960's



The ORP Gryf, a training vessel of the
Heroes of the Westerplatte Naval
High School



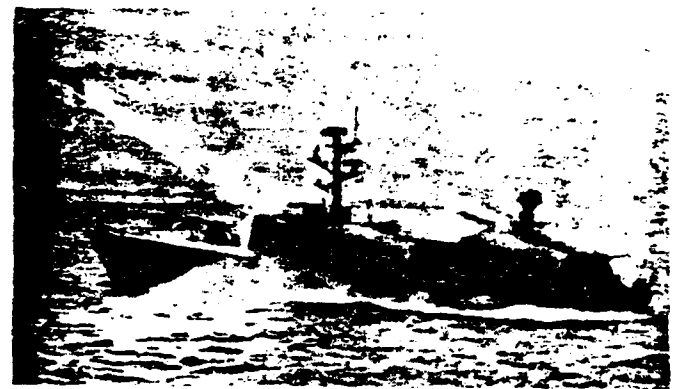
Fraternity arms three fleets: at the head of the formation is the destroyer, the ORP Grom, after it, the ORP Wicher, then a Soviet destroyer and a vessel of the East German navy



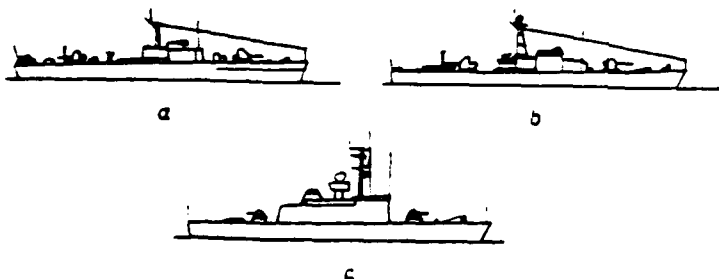
An exchange of flags. The Soviet crew presents its Polish comrades in arms a medium submarine



The firing of torpedoes from a torpedo boat

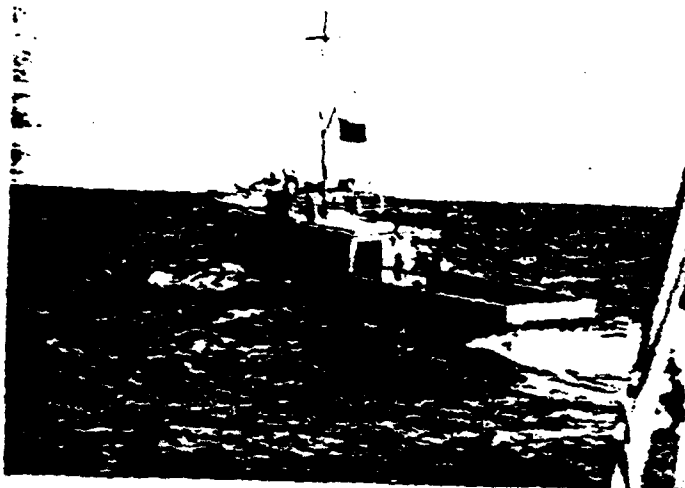


The firing of water-to-water rockets from the fore launcher of a small rocket ship



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Patrol ships built in Polish shipyards: a--the prototype series of a small battle ship; b--the same ship of a modernized, basic series; c--the second generation of the same ship of a basic series--it is a new type of ship in this class



A naval auxiliary unit adapted for the spotting out of torpedoes after training firing



Frogmen entering into a helicopter



A diver from a rescue-damage unit

4.2 CLASSES OF MODERN NAVAL VESSELS

The technical development of naval forces stems directly from naval theory. Political goals, the class character of the state, internal conditions and geographical conditions determine it. Doctrine then decides about the offensive or defensive character of anticipated operations and stemming from this the strategic, operational and tactical principles. From these come the organizational plans, training and the tactical-technical characteristics of the weaponry and equipment. States with great potentials are in the position to produce weapons adapted to their own doctrinal principles. States with a smaller potential adapt their doctrines to the production possibilities of their domestic industry, and economically backward states must modify the existing doctrine to the purchasing of equipment and armaments. The division of the world into two camps: the socialist and capitalist, has created the precondition for the formation of various doctrines connected mainly with ideology and politics, namely: a defensive doctrine represented by the Warsaw Pact and the doctrine of aggression designated in the NATO pact. The increasing dependence of military conceptions upon technical progress, and above all, the influence of weapons of mass destruction, is a sign of the times. The consequence of this is the disappearance from the oceans of armored vessels, such as ships of the line and heavy cruisers. Aircraft carriers and their newest modifications, helicopter carriers, however, have remained and are necessary for the air support of ships operating far from their land bases. The classes of vessels predominating numerically in today's fleets are chosen relatively strictly for their mission.

Destroyers were developed as a class at the beginning of World War I. Their first task was to fight torpedo boats and therefore were

officially called counter torpedo boat vessels until the 1930's. The classical destroyer connected artillery armament with torpedoes, but the speed of the development of automatic artillery, and from the 1940's--radar, redrew the torpedo attack capabilities of destroyers. The torpedo weapon was supplanted by the rocket; however, the first remained in the form of small anti-submarine torpedo launchers. With a certain simplification, it is possible to distinguish here two sub classes, the first with displacements between 4 and 8 thousand tons, which included light cruisers and was conventionally designated as a frigate. The second sub class has displacements between 2 and 6 thousand tons and a speed of between 32 and 40 knots. This encompasses types of destroyers. These are units well armed especially with anti-aircraft and anti-submarine weapons. The small units--around 2 thousand tons--are used for operations in closed seas and coastal waters. Therefore, the destroyer was transformed into a universal vessel able to effectively fight submarines, sea and air targets, possessing great fire power. Modern universal cannon of a caliber used on destroyers can fire in a certain period time as many heavy shells as two medium caliber cannon from World War II or one heavy cannon from World War I.

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Submarines are considered the main naval offensive weapon, especially since for the present no satisfactory way has been developed to attack a submerged vessel with weapons of mass destruction. Apart from the characteristic of vessels with atomic propulsion designated for strategic forces as nuclear rocket carriers, classically propelled ships have undergone considerable improvement in relation to units from the days of World War II. Thanks to the improved shape of the body and the perfection of electrical propulsion, underwater speeds of between 15 and 20 knots have been reached. The use of vents has allowed underwater operation at periscope depth with diesel propulsion, thanks to which submarines only provide a small target for

enemy aircraft. Therefore, these kinds of vessels are not equipped with artillery, but with topedoes, both of the classical type and with self-directing warheads. The adaptation of sonar to submarines has made torpedo attacks independent of optical periscopes. Among vessals with classical propulsion three subclasses can be distinguished: medium size ocean going vessals corresponding to the displacement of heavy submarines from the World War II period, units designated for operations in frozen closed waters with a displacement of 800-1500 tons and small units specially designated for engaging other submarines. The growth in the importance of submarines and their versatility has caused the intensive development of a series of specialized units in all classes of surface vessels and especially of small battle ships.

Small ships include fast units, whose common characteristic is operation in coastal waters and closed seas. Those included in the framework of the basic classes are: battle cruisers, tenders, anti-submarine gun boats and sweepers. Starting in the 1960's there has been a return to the development of small vessels in all the world's navies. This has been caused by doctrinal changes contributed to by the results of the Korean War, the aggression of the USA in Vietnam and that of Israel against the Arab countries.

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Battle cruisers. Included in this group of vessels are torpedo cruisers, rocket cruisers, artillery cruisers, diversion-landing cruisers and fast mine layers. With regard to the mission for whose performance great speed with small displacement is necessary, all these units are built on the base of torpedo cruiser bodies equipped with various weapon systems. The speed of battle cruisers exceeds 40 knots, and the standard displacement ranges between 100 and 200 tons.

Anti-submarine gun boats are larger than battle cruisers; their displacement amounts to between 150 and 500 tons. Their speed, however, averages at 40 percent less than that of battle cruisers, 25-30 knots. They are intended for coastal patrol, observation, tending mine fields, and guarding coastal lines of communication. They are equipped with a number of communication instruments and technical observation devices. Moreover, they are better on the open sea than battle cruisers and are more autonomous. Their relatively great speed facilitates observation and the effective tailing of enemy vessels. In comparison with the tactical advantage of the battle cruiser issuing from its greater speed, the artillery of the gun boat is more powerful both with respect to caliber and to the fire density.

Tenders are characterized by their greater displacement with regard to battle cruisers and gun boats, between 500 and 1500 tons, but are slower, at about 20-30 knots. Their main task, besides patrolling, is the detection and combat of submarines, because besides their powerful universal artillery, they are equipped with detection devices and anti-submarine weapons. Like the gun boat, they can defend landing units.

Base sweepers with displacements between 200 and 600 tons and regular sweepers with displacements between several tens and 200 tons are characterized by the greatest range of displacement and a speed between 15 and 20 knots. Their task is to destroy mine fields, because besides anti-aircraft artillery, they have versatile sweeping equipment. This is the largest class of small battle vessels.

It must be added that since the 1930's the mentioned classes have been considered to be auxiliary units, not playing an obvious role in naval operations. Only in World War II were their qualities appreciated and they entered into the framework of battle vessels.

Occupying the border between battle and transport ships are landing vessels, belonging to that group of ships intended not only for naval battle, but also for sea-land operations. The fire power and speed of maneuver of the modern battle vessels contribute to the growth of the operation's dynamism. Dynamism and intensity are the factors which characterize modern warfare. These factors stem from the development of operational resources, which must facilitate achieving the military target. One of these is the destruction of the enemy's forces on his coast. This is achieved in certain cases with sea landing or combined sea-air operations. The success of this type of operation depends on the rapid penetration of the coastal defense zone, and on another sequence--from the capture of enough of the enemy forces, allowing successful expansion into the interior. Subduing the anti-landing defenses can cause the attacking army considerable difficulty and naval forces can be engaged. It is equipped for this with the corresponding means of attack and military transportation, facilitating the accomplishment of the mentioned task. From the navy's point of view the most difficult mission from the initial landing is the taking of individual defense zones, and especially the obstacle belt built by engineers on the coast, in the shallows and on the beach. The slow speed of the landing craft makes them an easy target. The speed of landing craft cannot rationally be expected to be increased over 25 knots with the type of propulsion hitherto used. Over the years landing actions have changed their shape, beginning with the sea level formation during World War I, through the invasion battles of World War II, composed of waves of landing craft supported from the air, up to the modern spaced formation, in which aircraft

plays not only a defensive role, but makes up an integral part of the landing.

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Landing craft are intended for the transport of forces and heavy battle equipment to the landing site. The main characteristic of these vessels is their great load and their ability to ride high in the water allowing them to come up to the beach. They can be divided into two sub-classes: larger landing craft with displacements between several to several tens of thousands of tons, which cannot come up to the beach, unloading on roadsides or in ports; medium landing craft with displacements between 1000 to 1500 tons. These, thanks to their ability to ride high in the water, can come up to beaches and can unload equipment and personnel in so-called wading depths through landing gates opened in the front of the body. These vessels can land 5 to 10 tanks and other battle vehicles adapted for the surmounting of water obstacles. In order to support the units attacking the coast, the landing craft are armed with rockets or medium caliber artillery, as well as with automatic cannon adapted for use against medium and low ceiling airborne targets.

The technical characteristics of modern vessels. It is especially difficult to design small and medium vessels, because the period necessary for preparing multisided analyses, producing several design variants and developing the documentation is quite long and can amount to 30-50 percent of the series' construction time.

Experimental units have been built in small series where the period from the start to finish of the prototype's construction lasted between 4 to 5 years. The tactical usage life of smaller class vessels has its boundaries at 15 years. Prolongation of the usage life

by repair or modernization does not pay off, because the full modification of equipment and armament connected with total repair costs as much as building a new unit. As battle experience and operational analysis have shown, a unit's battle usage life has decreased considerably in comparison with World War II. In connection with this, the anticipated need for ships has doubled. Serial production, therefore, is unusually important with regard to the possibilities of supplementing the conditions of vessels during wartime. The continuous improvement of the equipment of vessels caused by the expansion of operational tasks already in the early post-war years has forced designers to deviate from obsolete design and construction methods. The excessive growth of the weight of units built according to traditional models had to be checked.

Two directions in ship construction have appeared since 1945:

--the continuation of traditional designs of the battle ship, in which, in connection with the growth of technology, displacement and engine power have been increased;

--the development of modernized designs, based on the newest achievements of technology, on ship design theories and a scientific analysis of battle missions, which lead to the optimal use of displacement and a lowering of engine power. Thanks to significant technical progress, already in 1955 the weight of small ships was reduced 20 percent while preserving their high battle worthiness. The economical design of the hull in regard to the weight and optimum utilization of the capacity allows the both the weaponry and the fuel reserves to be increased, which increase the vessel's range and offensive capabilities. Decreasing the hull's weight by a fourth will cause an increase in the speed by 10 percent and in the range from 30 to 50 percent. These measures are essential, in as much as 60 to 70 percent of the below deck space is designated for the preservation of mobility and the securing of the vessel's military operation. The

rapid development of design material has allowed the broad application of steel with increased durability, water resistant aluminum alloys and plastics especially in the form of laminates. Depending upon the dynamic loads which are many times greater in the bow than in the stern, the arrangement of the area is planned for the more important equipment to be located where the upward load factor is relatively small. From this arises the total modification of the traditional tendency of internal planning. This is not a trivial matter, since the upward load factor in the bow of a torpedo cruiser, sailing at a speed of 50 knots, is on the order of 10 G, while in the stern it is 10 times less. With a significant increase in dimensions, superstructures experience the consequences of an increasing number of devices installed in their interior.

Great technological progress has allowed the significant unit weight decrease of high-pressure engines, and the application of forked, radial or deltic systems in these engines has allowed the advantageous decrease of proportions, and above all, the shortening of length by 25-30 percent in comparison with engines from World War II. The introduction of gas turbines as the main engines in the 1950 s has allowed the construction of engines combined with high-pressure engines and combustion turbo systems. These, on one hand increase the maximum speed, and on the other--lengthen the unit's range from 20 to 30 percent compared to units running only on piston engines. And so, for example, in traditional designs from World War II, to get 26 knots of speed, the unit power amounted to around 28 KM/ton of displacement. The present figure has decreased on an average by 20 percent.

Besides basic weaponry, all classes of vessels are adapted to anti-aircraft warfare using all the artillery they possess and are equipped

with anti-submarine weapons. The majority of them--even torpedo cutters--can dispose of mines.

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Close in fighting presupposes the loss of a certain battle capability. Therefore, the means for securing a vessel's survival have a basic importance. Based on battle experience, the time it takes for a vessel to sink is from 2 minutes to 2 hours, depending on the where it was hit and the crew's preparedness for anti-damage defense. However, most of the ships were destroyed as a result of fires and ammunition or fuel explosions. Basic factors of anti-damage defense are: ensuring operation, anti-fire defense and anti-radiation protection. Modern ships have gas proof holds and are equipped with filter-ventilation devices.

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The development of automation and the growth of the number of tasks anticipated for smaller units has led to a several times increase of the weight share of electrical and electromechanical equipment in small battle ships since the last war. The cost of the electrical equipment has grown from several percent at the start of World War II to 30 percent of the entire value of the ship's serial production; it can be even more in prototypes. The mentioned devices have found use as:

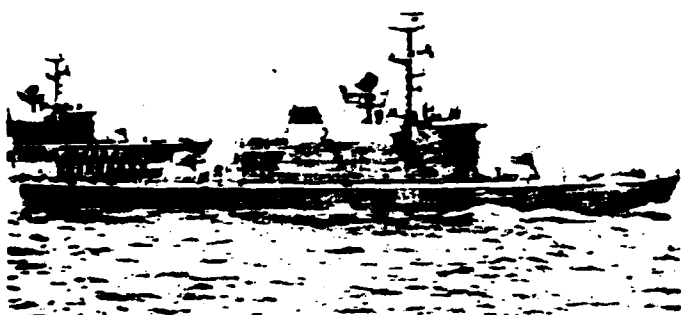
- detection systems: radar, sonar, thermal locating and dosemetric stations;
- directional systems: radio navigational and radar stations, automatic pilots, courseographs, logs and probes;
- remote control systems: with the power plant, aggregates, adjustable screws and other energetics devices;
- weapons' targeting systems: artillery, torpedo, anti-submarine, rocket control stations and other targeting devices, both optical and radar;

--command and communications systems: radar, radio telephones, external communications networks and special equipment (coding machines and computers);

--protective systems: demagnetizing equipment.

In connection with the development of automation has come the need for increased electrical energy supply. The unit power of an electrical installation amounts to over 1 kW/ton of displacement, which is three times more than that of merchant ships. The installation's light weight, the ease of transformation and adaption of alternating current has ultimately decided its usefulness in battle ships.

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A Polish designed anti-submarine gun boat



A base sweeper produced in Poland on a Soviet license

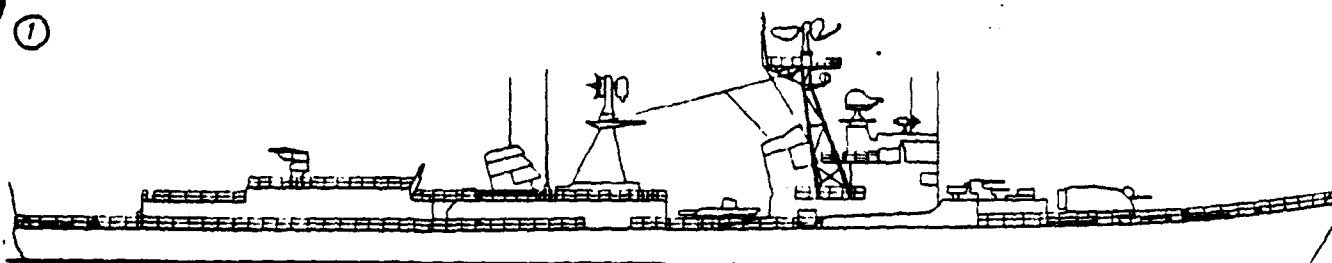


A formation of Polish designed base sweepers

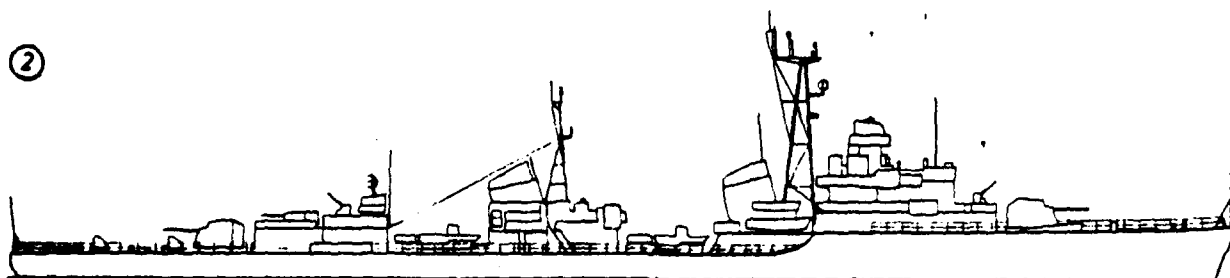


A tank column on the move

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②



③



Modern ships of the Polish Navy:

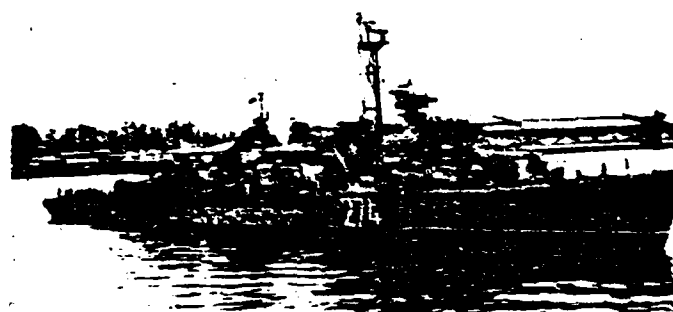
1. the destroyer, Warszawa; 2. the destroyer, Grom;
3. the submarine, Orzel.



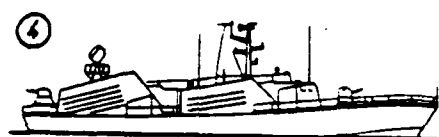
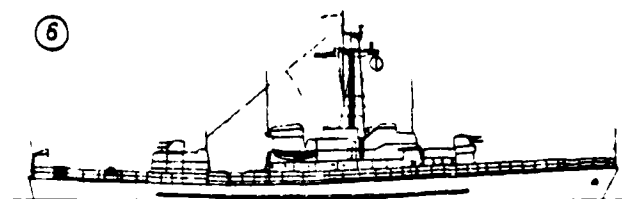
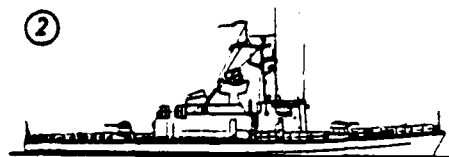
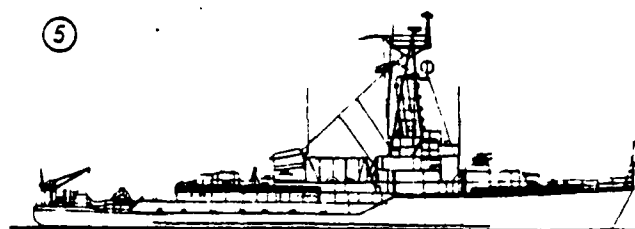
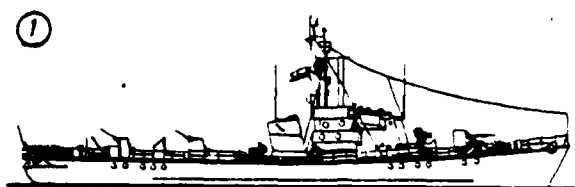
In front of a tank transport.



The ORP Warszawa, a destroyer--the flag ship of the Polish Navy--a modern rocket destroyer delivered to us by the Soviets.



The ORP Wicher, a destroyer--one of two twin ships delivered to Poland by the Soviets.

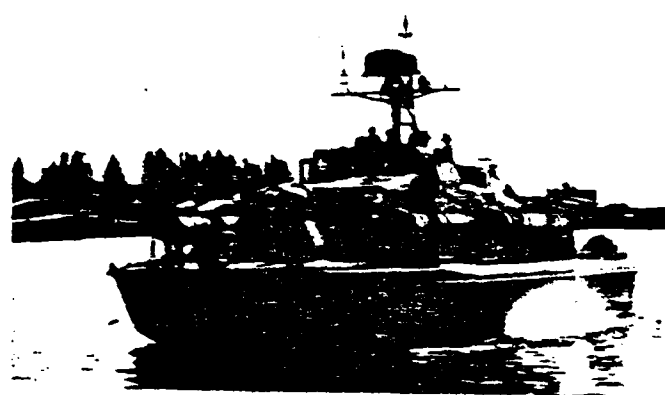


Modern ships of the Polish Navy

1. a Soviet designed anti-submarine gun boat, 2. a Polish designed anti-submarine gun boat, 3. a Soviet designed torpedo cutter, 4. a Soviet designed small rocket ship, 5. a base sweeper produced in Poland on a Soviet license, 6. a Polish designed base sweeper, 7. a sweeper-cutter produced in Poland on a Soviet license, 8. a Polish designed landing cutter, 9. a Polish designed landing craft



A torpedo cutter



A new torpedo cutter of Polish design with four launchers

4.3 DIRECTIONS IN THE DEVELOPMENT OF NAVAL TECHNOLOGY

In the final phase of World War II, the Americans used for the first time in human history weapons of mass destruction--the atomic bomb dropped on Hiroshima and Nagasaki. The operation, needless from the strategic point of view, was already then calculated as atomic blackmail in front of the world, and in particular, the Soviet Union and the nascent socialist states. Further experimentation with nuclear weapons demonstrated that ships could not be constructed which could navigate securely in the direct vicinity of an explosion. The development of aircraft and rockets, as warhead delivery systems prejudged the fate of heavy artillery ships, since a nuclear blast could easily sink both an aircraft carrier and a powerfully armored ship of the line, such as a destroyer. Therefore, modern fleets should possess vessels with small displacement, equipped with effective anti-aircraft weapon systems and reliable armaments, designated for accomplishing the tasks of a certain class of ship. The potential vulnerability of naval bases during a nuclear war forces the design of units which can operate with greater autonomy and range. Stemming from this, the long duration of naval operations exposes the unit to various meteorological conditions, requiring a vessel with a corresponding resourcefulness at sea.

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The definition of a battle vessel contained in the Service Regulations for Vessels of the Polish People's Republic (RSO) runs as follows: "A ship, which is suited to carry out battle tasks corresponding to its class, for which it was ranked...bears the title Ship of the Polish People's Republic (ORP)." The advantageous use of a vessel --in the sense of quality--is, therefore, the performance of battle tasks. This encompasses at least three partial operations: maintaining its own battle capability, perserving communications with its own forces

and observing the enemy's operations. The final effect arises from these operations, which is the destruction or other battle debilitation of the enemy. The vessel's goal--in the qualitative sense--is the success of the operations anticipated for its class. This can be the destruction of a ship of the same or superior class or ultimately the destruction of ships of every class. The result of this gradation is the modification of the value of individual targets, as well as operational factors for attaining the desired effect.

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The vessel's commander decides on the basis of the task acquired about initiating the corresponding operational factors. These are: the ship's level of technical competence, the battle's duration and location, the number of revolutions of the propulsion engines, the battle course and finally--the use of the weaponry. The factor of the operation, "battle duration and location", is internal to the effector, "fuel tanks", and is external to the effect, "fuel consumption". Fuel consumption, together with the other operational factor, "revolution", is internal to the effector, "propulsion engines", which is internal to "power". Power as an operational factor is internal to the effector, "propeller", which is external to "thrust", while simultaneously internal to the effector, "hull"; across this the propulsion engines return power, giving the ship the necessary speed. Another internality to the "hull"--is the "battle course", and the third external operational factor--"hydro-meteorological conditions". The negative influence of this factor is mitigated as the "vessel's level of technical competence" is increased. The three above externalities and the fourth "ammunition store" together with the fifth "use of the weaponry" make up internal operational factors or the effector of weaponry, which has only one external effect--"carrying out firing". The sum of the effects of the elements: carrying out firing, speed and the level of

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the resultant effect, created by the goal of achieving victory over the enemy.

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During the last 30 years the prerequisites of ship design have been reevaluated from emotional forms to functional ones. In order to grasp in full the logic of a design a sense of the general condition is not sufficient; not only is its present interesting, but its genesis is based on its prognosis. The direction of naval development depends upon the program of actualization, made up of the following stages: 1) the prototype's designing, 2) the construction of the prototype series, 3) the construction of the basic series, 4) the modernization of some units, 5) the construction of a modernized supplemental series. The next cycle is created from the new construction of the second generation basic series. Every ship has its own area of competence, in which it can achieve the assigned goal. Later, if the obtained effect does not correspond to the mission, it undergoes further modification.

Battle vessels are characterized by a specific property, which merchant ships do not possess, namely: an offensive capability, that is to say, the ability to achieve victory over the enemy, and therefore, the ability to achieve a goal with the corresponding numerical value. Therefore, the measurement of this characteristic considers, above all, the firing possibilities, speed and range.

The hull consists of a block connecting the design factors of operation with the operational effects. There are 4 internal and 5 external ones, which can be presented in the following way: external conditions--the vessel's stability; the propeller's thrust--speed; the battle course--the vessel's stability; unsinkability--

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navigability; ammunition store. The hydrometeorological conditions are independent of the hull; it must be designed, therefore, so that the disturbances caused by it will be as slight as possible. This concerns mainly the adaptation of the ship's stability and resistance to the most frequently encountered navigational conditions. Speed is a very important effect of the hull, whenever the proportion of the losses incurred by ships of an equal class during a battle is inversely proportional to the proportion of the quadrants of their speeds. Therefore, if the speed for foreseen goals is shown to be too slow, it is necessary to dispense with the classical hull and design a unit as a hovercraft. The correlation between unsinkability and navigability is an important condition, expressed by the hull's reserve volume with a higher water line. This reserve exceeds 100 percent of the ship's displacement and lessens the increase of submerged areas. The corresponding unsinkability is obtained with an operational hull on water proof compartments with transverse caging, and in larger ships also with lengthwise and deck caging. Practice has shown that the sides can be damaged at considerable lengths. The majority of problems in the skin involves the water proof caging, which causes the flooding of neighboring compartment. From this arises the postulate that the ship will function after the flooding of several compartments, that is to say it has multicompartmental unsinkability. 141

Practically, the largest compartment (which is for the power plant) even on small units will be no longer than 10 to 12 percent of the ship's total length.

The engine is adapted for operation in sea conditions with an energy transformer contained in the fuel, stored on the ship, in the mechanical energy, necessary for its propulsion. An important question is the selection of power guaranteeing the required speed. The guaranteed speed agreed upon is achieved in the ideal conditions of causal tests. The actual speed is around 15 percent less and is

achieved as the ship's battle speed. Usually, the engine's length should not exceed 60 percent of the power plant's.

Experience has shown that patrolling can be carried out at slow speeds not exceeding 10-15 knots. The main engines-calculated at the maximum speed--run under uneconomical conditions (at low revolutions and slight load, leading to a relatively large fuel consumption. Therefore, engines with an economic power (up to 30 percent of the power of the main engines) are installed. In this system, the economic engines are tied to the motion obtained at greater speeds, which ensure the connection of the main engines. In the others, used equally as often, the power plant system encompasses propulsion engines at about 50 percent of the total power and peak engines (which are most often combustion turbo units) connected together with the propulsion engines at the line of shafts when the ship must cross over to battle speed.

The gas tanks can be designed to be deep--this means stretching from the floor to the deck--or as it is done today, that is, situated under the water line. With regard to passive defense, the concealment of the fuel tanks under the water line is more useful; it worsens, however, the ship's stability as a consequence of lessening its metacentric height. On the other hand, the tanks are directly correlated with the propulsion engines for the ship's range and speed, which are functions of the engines' power and fuel store. Recapitulating: in order to obtain the maximum range, engines must be chosen, so that the power necessary to develop the speed, at which minimum resistance occurs, corresponds to the smallest unit of fuel consumption.

The integral effector, the "propellers", consumes the power supplied, by means of a line of shafts, by the propulsion engines in order to surmount the resistance of the hull's motion, which arises at a speed equal to the propellers' progressive speeds. The screw propeller is the most suitable for classical vessels; for hydroplanes, besides the screw propeller, water jet propellers can also be used. However, the adaptation of the airplane propeller is a useful development for the hovercraft. In connection with the necessity of adapting the characteristics of the screw propeller to working conditions, the screw propellers can be of a constant or alternating pitch--the so-called adjusting screw propeller. The screw propellers of battle ships are designed for a maximum feed, as the so-called advancing screw propeller. Sweepers and tugs are exceptions. Their screw propellers are designed for the maximum pull, as the so-called tug screw propeller. The maximum speed of a vessel with a conventional hull, at which the use of screw propellers becomes superfluous, is around 55-60 knots. If a greater speed is desired, the conventional hull must be discarded in favor of a hydroplane or hovercraft.

An essential effect for the final result is the operation of useful weapons. The accuracy of a weapon installed on the ship is less than that of a stationary weapon. The motion of the ship or that caused by the ocean's waves influences this; even a ship standing in calm waters experiences oscillations. Caused by oscillations, the ship's angular speed lessens that of the weapon's aiming at the target (the angular speed of modern universal artillery ranges between 30-90°/s), and therefore, lessens the chances of a hit. The oscillations' speed diminishes very rapidly with an increase of the ship's width, with an increase of the ship's submersion and with a decrease in the ship's metacentric height.

If the ship is equipped with immobile torpedo launchers, depth charge launchers and mine laying devices--the course stability has a far-reaching importance; this means the autonomous maintenance of the ship's constant course. Ships with greater speeds have better course stability, just as ships with greater relative lengths in relation to their widths.

The human factor should also be mentioned. After all, it makes up the crew which decides about the ship's application and the utilization of its operation as co-originators of the final effect. According to many observers, the psychological and occupational profile of crew members must significantly exceed the talent of the average man. The growing share of automation in controlling the ship's individual integral effectors does not eliminate the role of man; on the contrary--it increases the demands placed on him. Automation's task is the enemy's early detection, the precise determination of the attack position and the target's rapid covering with effective fire--but, this is only the first phase of the encounter with the enemy--the battle's further course and victory itself depend on the crew's preparation, on their physical and psychological resiliency.

The general developmental tendency of military vessels inclines towards an increase of speed, operational universality and the destructive power of the weaponry, while simultaneously increasing battle survivability. It aims, moreover, at limiting displacement and dimensions, decreasing production costs and the number required for the crew.

In connection with this, in the near future is anticipated the

introduction of different modifications of guided and non-guided rockets, and above all, the replacement of torpedoes with rockets, which have already effectively supplanted them. Rockets also replace conventional artillery, since their destructive power far exceeds that of artillery shells. Even small rocket ships can destroy any class of vessel. Only automated universal artillery, designated for anti-aircraft operations, will remain on ships. Fast sinking depth charges and self-aiming torpedoes have been introduced for anti-submarine warfare, but the rocket-torpedo will emerge in the near future, just as the rocket depth charge, which already is supplanting the conventional depth charge.

Atomic power has begun to power larger surface and submarine vessels. In connection with the rapid development of this type of propulsion, these installations will find particular application in average sized surface vessels such as frigates and destroyers. However, in general, combustion turbo systems, or popularly called, gas turbines, will be used for surface vessels of all classes.

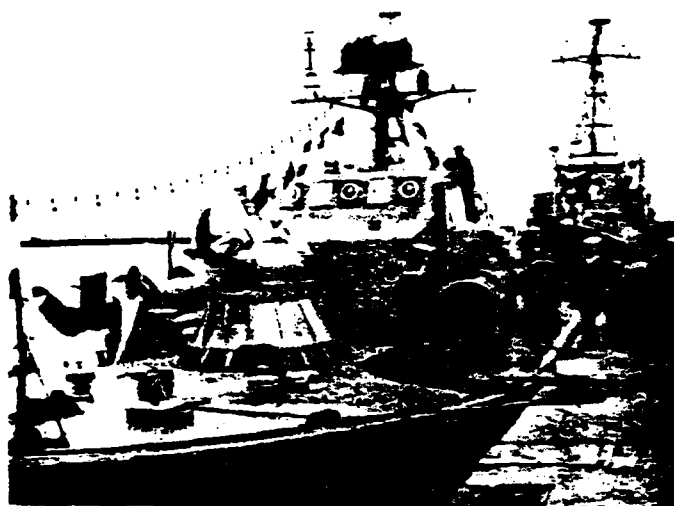
The design of conventional hulls for small vessels will gradually give way to faster hulls on carrying layers. Hydroplanes have already been introduced as fast anti-submarine vessels and cutters are presently enjoying the universal application of sliding hulls.

A specific issue concerns hovercraft, which will in the future be used instead of surface ships with several hundred or thousand tons of displacement. The minimal contact of the hovercraft's hull with the water makes it almost invulnerable to underwater weapons (mines, torpedoes) and permanent obstacles, which besides its great load and speed, destines it to be a landing craft unit. The design elements of

the hovercraft and its turboprop propulsion makes it more similar in its technological characteristics to heavy turboprop airplanes than to other ships. The aircraft industry, therefore, has contributed successfully to this branch of naval construction.

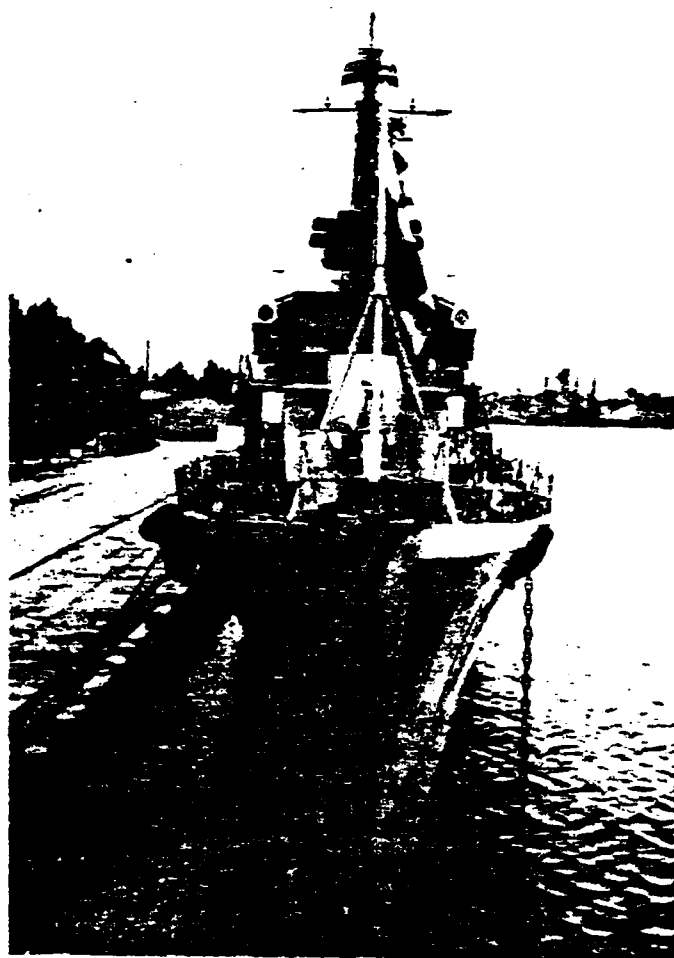
The maximum loading of ships with instruments and technical equipment is limited to the minimum number of places which are designated for personnel. Because of this small ships are much more dependent on land bases, where the crew lives and rests, coming on board only to perform some mission. In this regard, the organization of naval units is approaching that of the airforce and armor. The development of naval automation leads to the broad application of crewless vessels, which with regard to complexity must receive thoughtful technical protection at their bases. Therefore, in connection with this, naval bases will experience intensified development.

The navy of the Polish People's Republic--as other modern naval forces, and in particular the fleets of the Warsaw Pact countries--is realizing these aspirations, directions and tendencies of technological progress to the degree necessary to fulfill operational-tactical missions and to optimally cooperate with the other branches of the Polish Armed Forces, of which it is an integral part.



During the day honoring the navy;
in the front a torpedo cruiser and
behind it a sweeper; both vessels
are Polish designed

The ORP Grom, a destroyer--this unusual
frame shows the slender form
of the modern fast ship





Paratroop
exercises



Preparing an airplane for flight.



A 4 barrel naval anti-aircraft gun

5. MILITARY COMMUNICATIONS EQUIPMENT

5.1 COMMUNICATIONS EQUIPMENT OF THE POLISH PEOPLE'S ARMY DURING WORLD WAR II

During the war with the hitlerite occupier, the Polish Army was formed inside the Red Army, which certainly had to influence its organization, tactics and armament.

The communication units and subunits of the 1st T. Kosciuszko Infantry Division, and subsequently, the 1st and 2nd Armies, as well as the leadership of the communications organ, were organized in a similar way to those in the Red Army. The leadership of communications was facilitated by the appointment to high posts in the Polish Army of a considerable number of Soviet officers, people with excellent training and rich battlefield experience, who, because of a lack of responsible native command cadres, met the several personnel shortages. This also affected to a great degree military communications.

The equipping of communications units by the Soviets began with the 1st Division's organization and lasted through September 1945. These deliveries were free, and their size can be attested to by the number taken from the accounts of the communications department, connected to the General Headquarters of the Polish Army, according to conditions on September 1, 1947, shown in table 5.1.

The communications equipment listed in the table is not, however, the

full list of communications devices obtained from the Soviet Union during the war. It should be increased by the equipment destroyed during battle, as well as by that which wore out during use, beginning from the end of the war until September 1, 1947.

Besides deliveries of basic communications equipment, the Soviets supplied the Polish Army with replacement parts and useful materials. The size of this supply was sufficient to secure the equipment's effective utilization on the battlefield and to make possible the necessary repairs.

Better data concerning the military communications equipment of this period, in harmony with its operative division into radio and wire equipment, is of course limited. The division into radio and wire equipment arose from the method of communications organization adopted, which was generally arranged so that two independently operating and very loosely connected communications systems --radio and wire--were created. In order to acquaint the reader with the conditions of those times, we must define the concepts then operative.

Radio Equipment

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Radio equipment encompassed, above all, a rather wide assortment of field radio stations and radio receivers. At this time infantry units were equipped with the RP-12, RB and RBM portable low power telephone-telegraph, and the RSB medium power wire radio station. Operating on short waves, they ensured communications up to several

tens of kilometers. Tanks were also equipped with the 9-RS and 10-RK short wave radio stations, which allowed the maintaining of mobile communications over needed short distances. Artillery units possessed the 13-R low power short wave portable radio station and the A-7 ultrashort wave radio station. RAF and RAT radio stations ensured the radio communications of all levels of commands.

Besides those radio stations mentioned, the Polish Army possessed aeronautical and naval radio stations, as well as other surface radio instruments for various, strictly defined purposes.

The 13-R and A-7 low power, portable radio stations, had a series of joint assembly systems and elements, anticipated for both transmitters and receivers. With regard to design, they consisted of a joint transmitting-receiving block and could be used practically on one joint transmitting and receiving frequency. Their external casing was made up of a wooden or metal box, which also contained the power source's compartment. The other portable, low power radio stations (the RB, RBM and RP-12) had separate transmitter and receiver systems, placed in the so-called "transmitter-receiver apparatus box" and could operate on various frequencies within the radio station's range, using one common antenna. The power source of these devices was located in a separate box, called the "supply box", connected to the transmitter-receiver apparatus by a feed cable.

The linking of the receiver and transmitter in the majority of the mentioned radio stations was carried out by depressing and releasing the microphone's button, which allowed so-called "semi-duplex" activity. This facilitated the carrying on of conversations by the users of the radio stations, accustomed to communicating by

telephone, when it was necessary to remember that one had to depress the microphone's button in order to speak to the other party and to release it when they wished to listen to the other party.

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These radio stations also made possible the maintenance of communications with telephone users, whose apparatuses were connected by a two channel line at around 2 km with the radio station. From the receiver to the transmitter and back, the radio station had to, however, be connected by the radio telegrapher, who decided according to the conversation's content, whether the connection would be made.

Headphones were to be included in the complete radio, in order to facilitate the maintenance of communications by aid of a telegraph key, and in the design--a guide-bar for fastening the telegraph key.

Higher powered radio stations--the RSB--used in military communications in this period, predominately constituted, as mentioned above, the so-called "portable type." Especially, those devices, mounted in special boxes, carried by various forms of transport to the point where the radio station was to be set up, made a simple to use and suitable system. These could also be mounted on the chassis of really any type of automobile.

The RAF and RAT radio stations, as a rule, were used on motor vehicles. The RAT radio station was installed in a separate vehicle, with radio receivers, printers, etc., several hundred meters removed from the transmitting equipment.

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THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY 30
YEARS OF DEVELOPMENT(U) FOREIGN TECHNOLOGY DIV
WRIGHT-PATTERSON AFB OH H LATOS 20 DEC 83

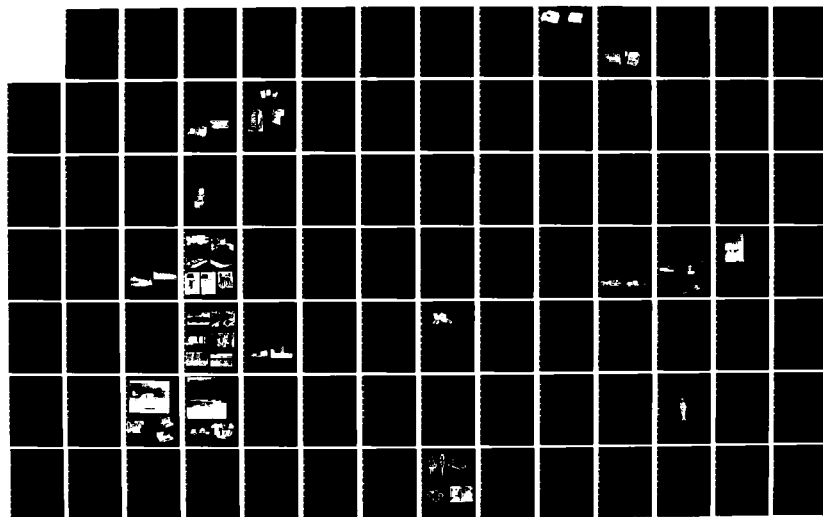
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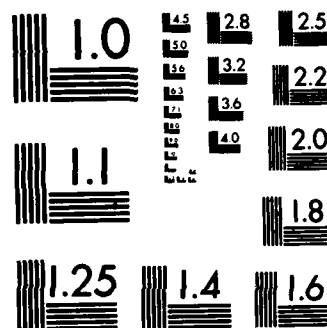
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

This entire assortment of radio stations was supplemented by radio receivers used individually or in a set with the transmitters of the individual types of radio stations, namely: the US-3S, US-4S, KS-2-SM, US-P6/12 and others.

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Although the frequency range of all the mentioned radio devices was often altered, the scales in the majority of them were characterized with the so-called "conventional wave bands", divided for operation into individual radio relations. The relatively small amount of conventional wave bands from tens to a little more than a hundred to a certain degree limited the wide use of radio equipment. The lack of a quartz frequency stabilizer in the majority of these devices also created difficulties in detecting the correspondent's signals and completing the connection, which was compensated to a certain degree by the radio telegraphers' great skill.

In contrast to the presently used voluminal construction (block, modular, panel, etc.), detached assembly was used in all the conventional radio devices--from element to element--with the maintenance of the shortest possible lines. Radio stations from the SCR group and American produced radio receivers made up a certain part of the radio equipment, obtained from the Soviet Union. Without entering into a deeper analysis of the technical parameters of the mentioned radio equipment, it is possible to discern that this equipment met the needs of the battlefield.

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The basic wire equipment in this period was made up by various types of field telephone apparatuses, telephone switchboards, Morse telegraphic apparatuses, ST-35 start-stop teleprinters, BODO

synchronized telegraphic apparatuses and one and two channel communications lines.

The communications units of the Polish Army possessed simultaneously UNA-F telephone buzzer apparatuses, UNA-FI telephone buzzer-inductor apparatuses and UNA-I inductors.

Besides these the army's communications were equipped with American produced EE field telephones.

KOF-33, FIN-6, PK-10, K-10 and PK-30 switchboards facilitated the connecting of telephone users. Some of them, as for example the FIN-6, were called numerators.

The simplest of the mentioned field telephone switchboards was the KOF-33, used above all in one channel telephone networks with the UNA-F buzzer type of apparatus. The ground played the role of the second channel in this case. This switchboard had terminals for the connection of lines from six users, a terminal for the "ground" connection, one teletechnical terminal, which allowed the connection of the conversational systems of telephone service devices to user lines, 6 teletechnical commutators, which allowed the interconnection of users, and also terminals for connecting the telephone service device. Under each teletechnical commutator was noted the cryptonym of each user. A common signal receiver for all the users of the switchboard was the telephone headpiece of the service device, and its buzzer was the transmitter.

The FIN-6 switchboard, also with six digits, contained individual signalling elements, by which the users were connected by means of communications cables. The UNA-FI telephone buzzer-inductor was a necessary component of the switchboard. It could operate in telephone networks, in which the users had UNA-F, UNA-FI and UNA-I telephones.

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The PK-10 ten digit switchboard, like the FIN-6 switchboard, was a universal device, to which, however, only 5 pairs of lines from users possessing buzzer telephones could be connected. It was possible, however, to connect the lines of users possessing telephone inductor apparatuses to all ten of the users' devices. The inductor call and the conversation's end were indicated in the 5 user inductor devices of this switchboard by telephone drop indicators, although in each one of the five devices--by neon lamps. The inductor calls and the conversation's end were indicated in the five buzzer devices of the switchboard by piezoelectric headphones and neon lamps. The PK-10 switchboard made possible the joint connection of 4 users who wished to have a circular conversation. The UNA-FI telephone was an essential part of its equipment. Increased attenuation during a conversation over the switchboard amounted to around .1 Np. Call indicators and end of conversation signals operated on the 2xPTF-7 line, at a level length of 10 km. The switchboard required 5 minutes to be set up and its weight was 12.5 kg.

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The K-10 and PK-30 telephone switchboards were used generally for the connecting of users possessing inductor telephones. The first of these allowed the commutation of ten pairs of user lines and inductor telephones were necessary for its service. The PK-30 switchboard was marked by broad technical possibilities. Of the thirty user devices, the last three served to obtain connections with the telephone

exchanges of the CB (central battery) or CBa (with automated exchanges) systems. They contained their own conversation system, and therefore, did not need a service telephone nor various call signalling systems (inductor, signal transformer, buzzer). A mouthpiece with call indicators (piezoelectric headphones and neon lamps) additionally attached to the switchboard served for the eventual reception of call and end of conversation signals sent by buzzer.

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Morse telegraph apparatuses of various types and years of production were basic devices designated for the transmission of telegrams during the war, and the ST-35 teleprinter and the 2-BDA-43 telegraphic device were key equipment for all levels of command.

Telegraph exchanges made possible the interconnection of telegraph users and the commutation of line feeders. Very simple 8x8, 16x16, 32x32 and 64x64 slotted switchboards with closed pins were used for them. The insertion of a closed pin where the two copper slots intersect, one horizontal, the other vertical, caused their short-circuit, and therefore, also the connection, for example, of two lines attached to these slots.

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Pole and stationary overhead lines were used at that time at all levels of command as basic communication lines. Initially, overhead lines with one channel (the second channel was the ground) were used; later, two channel lines were used. In many cases both telephone and telegraphic operations were carried out simultaneously on two channel pole lines. Line transformers (transformers with coil terminal systems) were used for this. They also tested the maximum utilization of the channel.

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PTF-7 telephone and PTG-19 telegraphic cables were widely employed in tactical units, divisions and subdivisions. They were characterized by great mechanical durability, very good insulation and sufficient conductance. The cables' great mechanical durability resulted from their being made of thin steel wire with a number of thin copper wires, necessary for the maintenance of the required conductance. The good insulation of these cables is attested to by the fact that communications were ensured for over a dozen days by lines made up of these cables, submerged in rivers or other water obstacles.

Given the technological level of those days, the mentioned wire equipment was an example of contemporary developments. This is demonstrated by the fact that with its aid, communications made command possible in the various types of battlefield operations in which our forces participated.

Table 5.1 The specifications of the communications equipment possessed on September 1, 1947

1. number, 2. specification, 3. number of systems or pieces, 4. portable radio centers, 5. high power radio stations, 6. medium power radio stations, 7. low power radio stations, 8. radio receivers, 9. telephones, 10. telephone switchboards, 11. telegraphic and teletype devices, 12. field cables, 13. instrumental systems, 14. battery charge systems

| 1 | 2 | 3 |
|-----|---------------------------------------|---------------------------|
| Lp. | Wyszczególnienie | Ilość kompletów lub sztuk |
| 1 | Węzły radiowe przewodne 4 | 4 |
| 2 | Radiostacje dużej mocy 5 | 2 |
| 3 | Radiostacje średniej mocy 6 | 224 |
| 4 | Radiostacje małej mocy 7 | 2 471 |
| 5 | Odbiorniki radiowe 8 | 288 |
| 6 | Aparaty telefoniczne 9 | 17 610 |
| 7 | Łącznice telefoniczne 10 | 905 |
| 8 | Aparaty telegraficzne i dalekopisy 11 | 533 |
| 9 | Kabel polowy 12 | 8 933 km |
| 10 | Zestawy narzędziowe 13 | 3 762 |
| 11 | Zespoły do ładowania akumulatorów 14 | 251 |

Table 5.2 Abbreviated technical data of some types of radio stations used in World War II

1. number, 2. specifications, 3. radio station type, 4. frequency range in MHz, 5. wave range in m, 6. number of conventional waves, 7. type of emission (working), 8. transmitter's power in W, 9. operator (soldiers), 10. time required to set station up and begin operation in min, 11. daily range possibilities (in km) with the use of an antenna, 12. bar antenna, 13. microphone, 14. key, 15. horizontal or radial dipole antenna, 16. microphone, 17. key, 18. mast or special antenna, 19. microphone, 20. key, 21. feed source, 22. incandescence, 23. anode, 24. the transmitter's voltage, 25. the receiver's voltage, 26. the total weight in kg, 27. total, 28. or, 29. buffer, 30. transformer, 31. transmitter, 32. receiver,

| Lp. | Wymagania | Typ radiostacji | | | | | |
|-----|--|-----------------|----------|-------------|------------------|--------------|-------------|
| | | 13-R | RR | RRM | RSB-P (nadajnik) | A-7-A* | A-7-B* |
| 1 | Zakres częstotliwości w MHz: 4 | 1,75 ÷ 4,25 | 1,5 ÷ 6 | 1,75 ÷ 6 | 2,5 ÷ 12 | 27 ÷ 32,12 | 24 ÷ 28 |
| 2 | Zakres fal w m: 5 | 70,59 ÷ 171,43 | 50 ÷ 200 | 50 ÷ 171,43 | 25 ÷ 120 | 9,37 ÷ 11,11 | 10,7 ÷ 12,5 |
| 3 | Numerów fal umownych: 6 | 70 ÷ 170 | 60 ÷ 240 | 70 ÷ 240 | 100 ÷ 480 | 270 ÷ 320 | 240 ÷ 280 |
| 4 | Rodzaj emisji (pracy): 7 | A1, A3 | A1, A3 | A1, A3 | A1, A3 | F3 | F3 |
| 5 | Moc nadajnika w W: 8 | ok. 0,5 | ok. 1 | ok. 1 | 5 ÷ 50** | ok. 1 | ok. 1 |
| 6 | Skład obsługi (żołnierzy): 9 | 1 | 2 | 2 | 5 | 1 | 1 |
| 7 | Czas rozwinięcia i uruchomienia w min.: 10 | 2 ÷ 3 | 2 ÷ 3 | 2 ÷ 3 | 15 ÷ 20*** | 2 ÷ 3 | 2 ÷ 3 |
| 8 | Możliwy do osiągnięcia zasięg w dzień (w km) z zastosowaniem anteny: | | | | | | |
| | a) prętowej: 12 | | | | | | |
| | mikrofonem: 13 | 10 | 7 | 9 | — | 8 | 12 |
| | kluczem: 14 | 17 | 12 | 16 | — | — | — |
| | b) dipolowej poziomej lub promieniowej: 15 | | | | | | |
| | mikrofonem: 16 | 18 | 10 | 16 | — | 15 ÷ 20 | 15 |
| | kluczem: 17 | 25 | 17 | 35 | — | — | — |
| | c) masztowej lub specjalnej: 18 | | | | | | |
| | mikrofonem: 19 | — | 30 | 25 | 75 | — | — |
| | kluczem: 20 | — | 50 | 50 | 100 | — | — |
| 9 | Źródła zasilania: 21 | | | | Ogólnie: 27 | | |
| | a) ładowanie: 22 | 2NKN-10 | 2NKN-22 | 2NKN-22 | 1.-3/2 + GS-1000 | 2NKN-10 | 2NKN-V-10 |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----|--------------------------------|----------------------------------|----------------------------------|----------------------------------|---|-----------|-----------|
| | b) anodowe: 23 | 4x BAS-60 lub 23 3x BAS-80 | 4x BAS-60 lub 28 3x BAS-80 | 4x BAS-60 lub 28 3x BAS-80 | + buforowo 29 6x 4NKV-60 | 2x BAS-80 | 2x BAS-80 |
| | napięcie dla nadajnika w V 24 | 200 | 200 | 200 | Przetwornice: nadajnik — 30 RUK-300W 31 | 160 | 160 |
| | napięcie dla odbiornika w V 25 | 120 | 120 | 80 | odbiornik — 32 RU-11A | 160 | 160 |
| 10 | Masa ogólna w kg 26 | 20 | 28,5 | 28,5 | — | 21 | 24 |

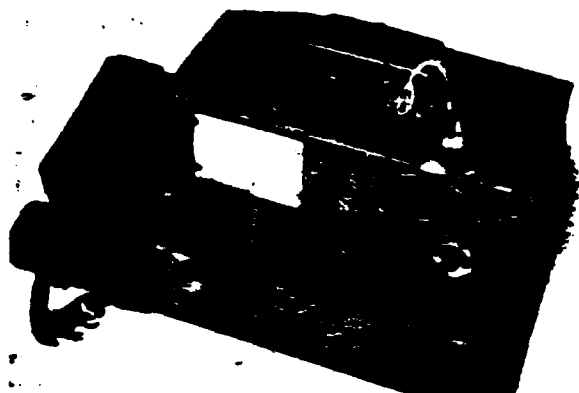
Notes:

*The A-7-A and A-7-B radio stations are modifications of the A-7 radio station. They were part of the equipment of the later period.

**The great range of the changes of the transmission power of a transmitter with antenna resulted from its relatively wide frequency range. The greater the power the less the frequency.

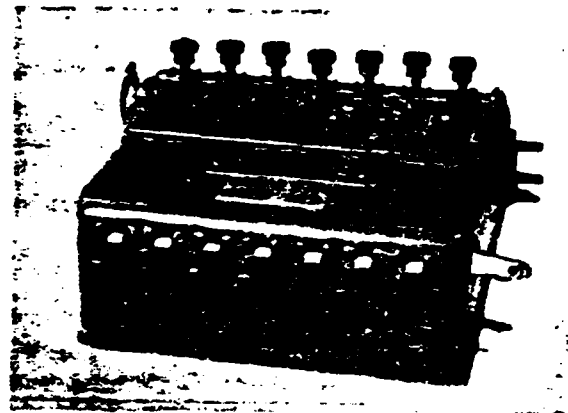
***The time required for setting up and beginning the operation of the RSB-F radio station was average and in principle like those mounted in motor vehicles. It also includes the time necessary for setting up the mast antenna.

p. 153



The US-P6 radio receiver

p. 155



The KOF-33 simple telephone switchboard

Table 5.3 Abbreviated technical data of some types of radio receivers used in World War II

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1. number, 2 specifications, 3. type of radio receiver, 4. frequency range in MHz, 5. wave range in m, 6. number of conventional waves, 7. sensitivity in μV , 8. course of receiver's sound transmission, 9-10. course of receiver's telegraphic signals, 11. voltage of incandescence circuits in V, 12. Current consumption in incandescence circuits in A, 13. voltage of anode circuits in V, 14. current consumption in anode circuits in mA

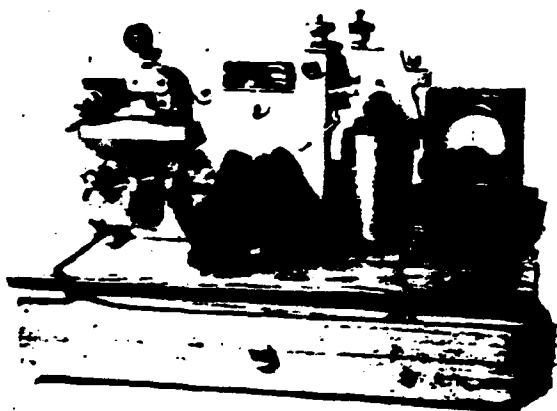
| Lp. | 2 Wyszczególnienie | 3 Typ odbiornika radiowego | | | |
|-----|---|----------------------------|------------|-------------------|------------|
| | | KS-2-SM | US-P6 | RSI-4T (totalizy) | KWM* |
| 1 | Zakres częstotliwości w MHz | 2,5 ÷ 12 | 0,175 ÷ 12 | 3,75 ÷ 6 | 1,3 ÷ 27,4 |
| 2 | Zakres fal w m | 25 ÷ 120 | 25 ÷ 1714 | 50 ÷ 80 | 11 ÷ 200 |
| 3 | Numerów fal umownych | 100 ÷ 480 | 7 ÷ 480 | 150 ÷ 240 | — |
| 4 | Czułość w μV : | | | | |
| | — toru odbioru fonii | — | 2 ÷ 10 | — | ok. 3 |
| | — toru odbioru sygnałów telegraficznych | — | 1 ÷ 4 | — | 1 ÷ 4 |
| 5 | Napięcie obwodów żarzenia w V | — | 6,3 | — | 2 |
| 6 | Pobór prądu w obwodach żarzenia w A | — | 2,3 | — | 1,1 |
| 7 | Napięcie obwodów anodowych w V | — | 200 | — | 80 |
| 8 | Pobór prądu w obwodach anodowych w mA | — | 30 | — | 25 |

*The KWM receiver was part of the equipment of the communications forces at a somewhat later period.

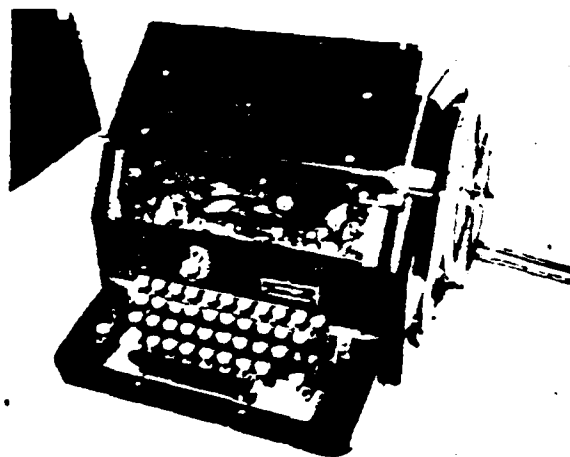
Table 5.4 Technical data of UNA type telephones

1. number, 2. specifications, 3. type of apparatus, 4. year of model, 5. source of the call signals, 6. decreased attenuation in Np, 7. communications range in km, 8. on 2xPTF-7 field telephone lines, 9. on 2xPTG-19 field telegraph lines, 10. on steel overhead lines (3mm), 11. on copper overhead lines (4 mm), 12. feed source, 13. cell type, 14. feed voltage in V, 15. weight in kg. 16. dimensions in mm, 17. type of casing, 18. buzzer, 19. buzzer and inductor, 20. inductor, 21. wood

| Lp. | 2 Wyszczególnienie | 3 Typ aparatu | | |
|-----|---|-----------------|------------------------|-----------------|
| | | UNA-P | UNA-FI | UNA-I |
| 1 | Wzór z roku 4 | 1943 | 1943 | 1943 |
| 2 | Źródło sygnałów wywoławczych 5 | brzęczyk 18 | brzęczyk i induktor 19 | induktor 20 |
| 3 | Pokonywane tłumienie w Np 6 | do 4 | do 5 | do 4 |
| 4 | Zasięg łączności w km: 7 | | | |
| | — na polowych liniach telefonicznych 2xPTF-7 8 | 25 | 30 | 25 |
| | — na polowych liniach telegraficznych 2xPTG-19 9 | 40 | 50 | 40 |
| | — na stalowych liniach napowietrznych (ø 3 mm) 10 | 120 | 175 | 120 |
| | — na miedzianych liniach napowietrznych 11 (ø 4 mm) | 500 | 600 | 500 |
| 5 | Źródła zasilania: 12 | | | |
| | — typ ogniwa 13 | 3S | 2x3S | 3S |
| | — napięcie zasilania w V 14 | 1,5 | 3 | 1,5 |
| 6 | Masa w kg 15 | 3 | 7,6 | 5,6 |
| 7 | Wymiary w mm 16 | 280 x 105 x 155 | 286 x 115 x 235 | 286 x 123 x 185 |
| 8 | Rodzaj obudowy 17 | drewniana 21 | drewniana 21 | drewniana 21 |



A Morse telegraphic device



The ST-35 tape teleprinter

Table 5.5 Abbreviated technical data of teleprinters and telegraphic devices used in World War II

1. number, 2. specifications, 3. type of apparatus, 4. Morse device, 5. transmission method, 6. telegraph key, 7. by aid of an alphabetic keyboard, 8. by aid of a special 5-key keyboard, 9. print out of the received information, 10. on a paper tape in the form of dots and dashes, 11. on a paper tape in the form of letters and numerals, 12. on a paper tape in the form of letters and numerals, 13. amount of words per hour, 14. maximum, 15. practical, 16. range in km, 17. direct, 18. on fixed lines, 19. on pole lines, 20. at their practical length, 21. on 2xPTG-19 field lines, 22. with the use of transmission translation, 23. feed, 24. line, 25. voltage in V, 26. current intensity in mA, 27. motor, 28. stationary, 29. voltage in V, 30. current intensity, 31. time required for setting up and regulation in min, 32. total weight in kg

| Lp. | 2 Wysszczególnienie | 3 Typ aparatu | | |
|-----|--|--|---|---|
| | | Morse a wz. 43 | ST-35 | 2-BDA-43 |
| 1 | Sposób nadawania 5 | kluczem telegraficznym 6 | za pomocą klawiatury alfabetycznej 7 | za pomocą specjalnej klawiatury 5-klawiszowej 8 |
| 2 | Wydruk odbieranej informacji | na taśmie papierowej w formie kropek i kresek 10 | na taśmie papierowej w formie liter i cyfr 11 | na taśmie papierowej w formie liter i cyfr 12 |
| 3 | Wydajność słów na godzinę: 13 | | | |
| | — maksymalna 14 | 700 | 4500 | 6000 |
| | — praktyczna 15 | 400 | 1250 | 4000 |
| 4 | Zasięg w km: 16 | | | |
| | a) bezpośredni: 17 | | | |
| | — na liniach stałych 18 | 300 | 250-300 | 600 |
| | — na liniach tyczkowych 19 | na praktyczną ich długość 20 | — | — |
| | — na liniach połowych 21 | 75 | 40-50 | — |
| | 2xPTG-19 | | | |
| | b) z zastosowaniem translacji przekątnikowych 22 | — | 600 | 2000 |
| 5 | Zasilanie: 23 | | | |
| | a) liniowe: 24 | | | |
| | — napięcie w V 25 | do 120 | 80-160 | do 110 |
| | — natężenie prądu w mA 26 | 10-15 | 40-50 | 15-25 |
| | b) motorowe 27 | — | 110-120 V = lub 127 V ∞ | — |
| | c) miejscowe: 28 | | | |
| | — napięcie w V 29 | — | min. 80 | 110 |
| | — natężenie prądu 30 | — | 40-50 mA | 1.3-1.9 A |
| 6 | Czas rozwijania i regulacji 31 | | | |
| | w min. | 5-10 | 10-15 | ok. 30 |
| 7 | Masa ogólna w kg 32 | — | 35 | 325 |

5.2 MILITARY COMMUNICATIONS EQUIPMENT OF THE EARLY POST-WAR YEARS

During the post-war months of 1945 the leading economic factors worked out a plan of economic development for the first time in the history of Poland. It was anticipated to last for three years. The goal of this plan was to achieve a level of economic development sufficient to meet the most urgent material needs of the population.

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The economic policy of Poland, adopted during the first three years after the war, was faithfully reflected in the economic activities of the army, including the communications forces. Above all the Communications Department of the MON was aware of the need to preserve the condition of the equipment with which it ended the war for the next several years. It especially calculated that all efforts had to be directed to maintaining the equipment in the best possible technical condition and to demonstrate the maximum of effort in prolonging its usage life. The realization of this exceedingly important task was seen in the form of increasing the training of communications personnel, increasing total attentiveness toward the equipment's technical condition and its economical utilization. It also took the form of the allocation of the necessary resources for conservation, exploitation and repair. At the same time a broad path was opened to all initiatives aimed at improving the communications equipment possessed in the individual units.

If we admit that our country did not possess an adequate base of subsystems or tele- and radiotechnological elements and electronic elements were only a dream, that every relay, commutator, gauge, resistor or condenser, and even every piece of cable, was considered to be as valuable as gold, that ultimately these elements were

obtained from old and captured devices, then we can begin to imagine the difficulties met in implementing even a semblance of this modest task.

During this difficult period we did not, however, give up on the many tests carried out, which ultimately ended with success, and were aimed at modernizing communications equipment and meeting the growing shortages, by utilizing and broadening the possibilities of domestic production in the military and inspiring the national resourcefulness, thus restoring industry. All communications equipment, henceforth, was divided into radio or wire in accordance with nomenclature adopted earlier. In this way were made the efforts to accomplish the tasks placed in front of the communications forces.

RADIO EQUIPMENT

Radio equipment, and especially radio stations, ensured command for forces under battlefield conditions. These conditions underwent serious and fundamental changes. The securing of radio communications between permanent garrisons and inside of them, between military units dispersed over the national territory, began to run into difficulties. In the existing radio station systems with antennae, the receiver's several or tens of watts was not sufficient to cover the actual distances. In this situation, besides the intensive training of radiotelegraphers, every effort was directed at fully utilizing the possibilities of radio equipment, and above all on increasing the intensity of the signal field at the reception point by designing very effective directional antennae and developing a corresponding antenna field. This direction of operation bore rather positive results. The maintenance of communications by aid of low power 1 W

short wave radio stations was somewhat improved at a distance of 150 km, and even at 300 km there were no instances of individual breakdowns. Obviously, there was no solution at this time to the problem of the so-called "dead zone", which encompassed an area from several tens to 150 km from the radio station.

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At the same time major efforts were directed at the maximum utilization of the relatively small number of high power radio stations. It was felt that one transmitter of such a radio station was in the position to simultaneously maintain communications on two or three radio reports. There arose, therefore, the concept, already practically tested during the war, of radio operation in the so-called "radio bureau" system. This was implemented on a broad scale in 1948, when it was used not only in stationary but also in field radio communications systems. The matter dealt with separately located radio receivers, which, making up a so-called "reception central", with the aid of switchboards or over manipulation and service cables (dispatchers) could be connected with any transmitter of the so-called "transmission central", located at a fixed, and sometimes great distance from the reception central. In the majority of cases, one transmitter cooperated with two radio receivers.

Besides this, in the mentioned period, and especially in its first years, a series of different types of network feeders for portable radio stations and radio receivers was designed. This made possible, on one hand, the training of radiotelegraphers under the conditions of a permanent training base, and on the other--the economical use of the BAS-60 and BAS-80 anode batteries, whose production had just begun in Poland.

Ardent radio amateurs* in military uniforms took over the equipment of the training bases with the necessary training assistance from the fields of electrotechnology, radio technology and teletechnology, facilitating the effective training of their younger colleagues. From their hands came a series of individual assembly elements, schematic designs and actual working models of systems and devices, and even fully cabled and equipped stations for servicing radio traffic, joined to acoustical signal generators and connected fields. It should be remembered that between 1945 and 1947 buzzer telephone devices, whose buzzers were connected with telegraph keys by acoustical signal generators, made up the fundamental training aids in many communications divisions and subdivisions. All of these developments not only promised, but at the same time stimulated, further, intensive work.

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WIRE EQUIPMENT

The basic direction of the technical development in the field of wire equipment during the mentioned period was the adaptation of the equipment base possessed to the securing of communications for forces dispersed in garrisons and--corresponding to the new conceptions adopted for the communications system--under field conditions. Accordingly, this was begun individually in separate communications units, and above all, regional and divisional communications units, since in 1948 under the general technical direction of the Studio Division created in the Communications Department of the MON, we were occupied with the realization of individual "elements" and the total communications center. This concerns both the technical relationship of the equipment in order to fully utilize its possibilities, and the design of specially connected new systems and auxiliary equipment--beginning with all types of carrying cases and frames,

tables, etc., and ending with various instrument boards and feeders.

Used equipment and that abandoned in Poland by the occupier made up the base of subsystems and assembly elements for new designs. At this time there were designed and produced many individual types of wire centers for the communications of different command levels, control-test points (PKB) and telephone-control points (PKT). New telephone exchanges and telegraph commutators with different capacities corresponding to local requirements, feed and switchboard instrument boards, measurement devices, feed stations and a series of other devices were also designed. With the exception of telephone and telegraphic devices, some telephone switchboards and feed sources, the majority of devices were produced domestically in order to meet command needs, which were considerably greater than those during the war.

"Pretend" exercises of the communications forces with part of the headquarters and forces of other branches of the military were frequently performed as a way to gauge how well these needs were being met by the designed equipment. Demonstrations in the units and exhibitions of communications equipment were organized really every year as a basis for the exchange of information and experiences in the production of equipment.

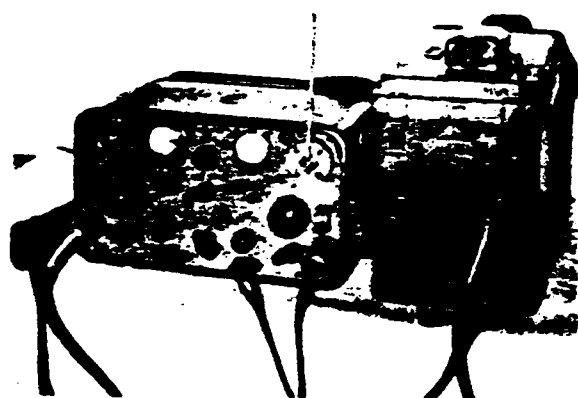
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At the same time communications lines subunits--also within the domestic scope--perfected methods for the rapid construction of fixed, pole and cable overhead lines. Various types of vehicles were adapted for the transport of needed material; and cable cars, carrying frames, reels, cable hooks, etc. were also constructed. Laboratory and open training bases were set up.

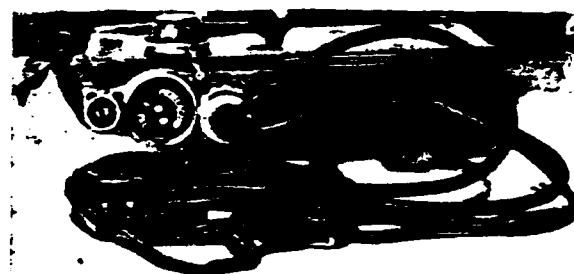
All of these activities stemming from the concrete needs of the moment contributed to a certain degree to the brisk pace of the regeneration of the teletechnical industry, which, inspired by the leading organs of the Ministry for National Defense, had already begun in 1947-48 to produce the AP-48 field telephone and C type field cable, which replaced the very worn PTF-7 and PTG-19 cable. By the end of the 1940's the LP-10 and LP-30 telephone switchboards had also begun to be produced.

Admittedly, because of the domestic industry's lack of experience in producing military equipment and because of imperfect production technology, unpolished subsystems and assembly elements did not pass usage tests under difficult field and climatic conditions. However, factory teams, technical leadership and technical workers of the leading organs of the communications forces finally obtained the necessary experience and practice by this route. This was to bear fruit in later years and positively influenced the civilian production of the Polish teletechnical industry.

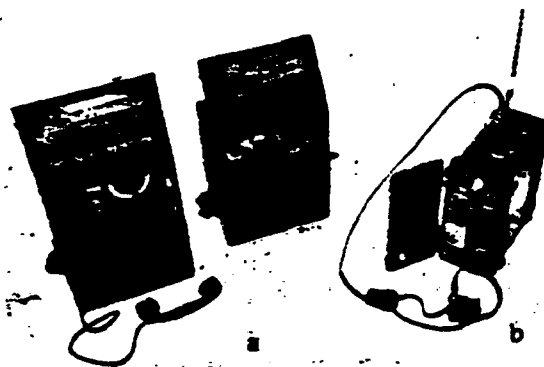
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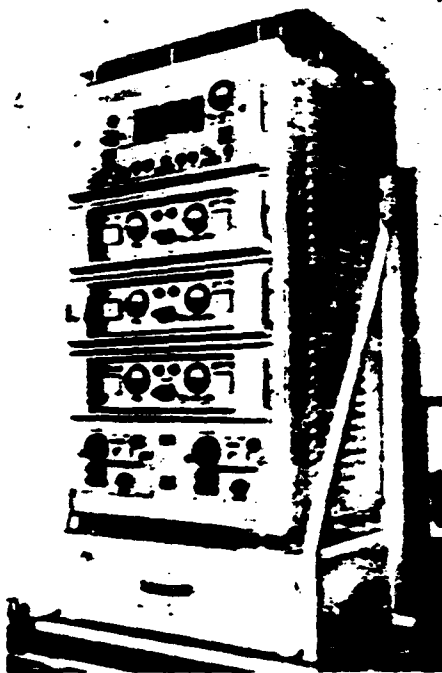
The RBM-1 radio station ready
for operation



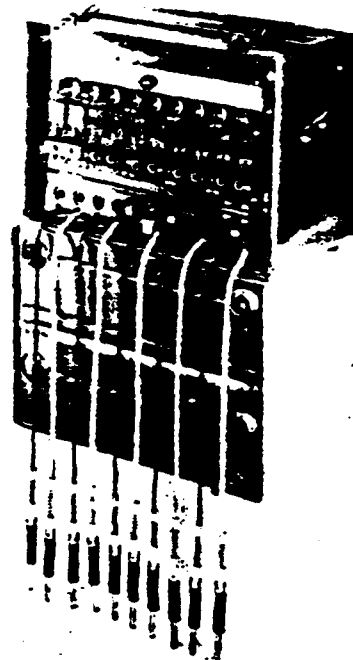
The R-116 radio station



A comparison of the A-7 radio station (a) with the same class new generation R-108 radio station (b)



The FT-3 multiplying
telegraphic device



The LP-10MR radio-telegraph
field switchboard

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5.3 MILITARY COMMUNICATIONS EQUIPMENT BETWEEN 1950 AND 1973

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The period from 1950 until today, from the point of view of the technical development and progress of military communications, can be divided into several stages. In order to simplify the characterization of the general situation in this area, we will make two divisions, the first from 1950 until 1957 and the second from 1958 until today.

The first stage, beginning early on, was marked by the rapid development of systems of mass destruction and the army's total mechanization. The earlier views on how to utilize forces in battle operations and those on command methods were totally altered. The demands concerning both the systems and the equipment were, therefore, also altered. The introduction of new battle systems and the appearance of new types of forces and services all demanded the modernization of military command equipment, which pulled after it the need for the rapid development of communications systems and the organizational-technical change of the earlier established communications systems.

A rather wide spread industrial base adapted to the production of a broad assortment of communications devices, based on licensed documentation and domestic designs, arose in Poland. The conditions, hence, existed for the replacement of worn equipment. The Chief Communications Inspectorate created the base which ensured the appropriate level of equipment readiness from the side of the theoretical designing, planning and coordination of all technical operations. As mentioned earlier, the Studio Division operated in this field, and subsequently, a specialized technical division was

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formed, initially run by the Poligon, later by the Communications Equipment Research Center, and finally by the Military Communications Institute.

The continuous widening of contacts with industry required the regulation and stabilization of the forms of cooperation, especially in the realm of production for the army.

Taken generally, the second stage of the period in question, and especially its beginning, was the result of the activities of the first and mainly its qualitative developments.

Very demanding criteria were adopted for the evaluation of communications equipment. Initially, this equipment was evaluated according to its reliability and operational speed, the accuracy of transmitted information, the time required for making connections, security and effectiveness. The desire to meet these complex requirements influenced all future technical activities. A sudden increase in the number of communications channels ensued, which led to a significant development of transmission devices.

The development of the base of subsystems allowed the systematic decrease in the dimensions and weight of modern communications equipment. The increase of the military's fire power, its mechanization and the speed of operation demanded the systematic automation of command processes and the shortening of the time necessary for the command system's reaction. The need arose for the very close connection of appropriate communications equipment in a uniform, complex system, securing both stationary and mobile

communications for commands and headquarters under various conditions.

The CMEA played a far reaching role in the period in question, and still does. Thanks to it, the concentration of the investment, research, design and production efforts of the individual member states on a limited number of questions became possible, without the need for wasting time on the many problems which interested each of the states. In the field of the production of military communications equipment, the positive effects of membership in CMEA were especially visible in the form of new equipment, which was distributed to the necessary units.

From the 1950's on, a series of important concepts were viewed differently. The one-time clear demarcation between radio and wire equipment gradually blurred. It was no longer possible to simply ascribe a piece of equipment to any defined group when complex systems for the utilization of equipment existed where information frequently reached its destination via varied types of transmission devices. Even telephones or teletypes, once counted as wire equipment, now can secure communications over radio or radio link transmission devices. New concepts have been formed, stemming from the development of communications technology, from the enlargement of the assortment of devices and their possibilities. Comprehension of this matter allows one to understand the dissimilarity of the division of communication equipment and devices into subdivisions in relation to those previously used.

COMMUNICATIONS CENTERS

A great deal of attention has been devoted in the last few years to communications centers, as a complex of organically and technically interconnected devices, spread around in a region and designated for the securing of command and staff communications. Corresponding to the existing conditions and possibilities--not only technical--communications centers in the last period were realized by communication units, corresponding to local needs. Essentially, their common characteristic was that their basic elements, telephone and telegraph stations, feed stations, radio junction reception exchanges, etc., were portable. The equipment, which made up the center's individual elements, was transported to the designated region, often already installed in corresponding transport cases, which, upon opening, also acted as furniture. The technical treatment of individual communications apparatuses was not standardized. Their design or even that of the entire center was modified according to the needs of the times. 158

Such a situation could not last indefinitely, when on one hand it caused certain exploitation difficulties for the communications system, and on the other, unforeseen technical complications. The Chief Communications Inspectorate of the Polish Army, and later the Chief of the Communications Forces of the MON, concerned with this problem and considering it not only from the point of view of present, but also of future needs, began working out standardized communications centers with special design documentation for individual command levels. Subsequently, standardized communications centers appeared for all command levels. This initially dealt with portable centers, but later included mobile ones, based on the first post-war generation of equipment, and from 1957--on new equipment, signifying an expressed increase in quality. Produced by industrial methods, the Dukat or RWL communications centers are expressed proof of this. The organizational, technical and even

production problems of communications centers were solved by military specialists.

COMMAND AND STAFF VEHICLES

When the entire military was mechanized, the need arose for its equipping with command, command-staff or special staff vehicles, containing communications systems, facilitating various levels of mobile command, and allowing staff officers--also on the move--to obtain information about the position and situation of both their own and enemy forces in order to facilitate command decisions. After all, rapid maneuver, which has become one of the basic factors of modern warfare, cannot be realized without the constant maintenance of communications with superiors, subordinates and collaborating forces. Documentation, therefore, was worked out in the communications forces, as were models of vehicles equipped with various types of communications devices, which corresponded to the needs of the various branches of the armed forces. The production of these vehicles, realized in Polish factories, allowed the growing needs in this field, which started in 1963, to be met.

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The majority of the mentioned communications devices, besides the fact that they secured communications with radio or radiotelephone correspondants, can also be connected while mobile with any user of the wire or radio link network. These motor vehicles are not differentiated internally from other vehicles of the same type with certain exceptions.

RADIO TRANSMISSION EQUIPMENT AND DEVICES

The radio industry had already appeared in an earlier period, and since 1953 the radio technical subsystem industry had undertaken the serial production of military radio equipment. Up until this period, the equipment in the communications units was all quite old. Production was begun, therefore, of modernized types of wartime radio stations, such as the RBM-1, RSB-F-3, RAF-KW-5, the 10-RT tank radio station, the US-P6 radio receiver and also--in the later half of the 1950's--a small radio station. This was the second post-war generation R-116 radio station, designated for the smallest command cells. The army's successive supplying with this equipment resulted in 1957 in the complete renewal of the equipment base in this area. Both high power radio stations were produced, above all, in a mobile version--for motor vehicles.

Soon afterwards, the production of several other types of second generation radio stations was begun. These were a qualitative step forward in the technical and exploitation respect. They were low and medium power radio stations, designated for tanks and the infantry, one and multichanneled. Their production satisfied the total need of our army for these types of devices. The remaining groups of needed radio stations and other radio equipment were imported.

Thanks to the great frequency stability, all the equipment of the new generation was characterized by the possibility of connection and the maintenance of communications without seeking the signals of the correspondant or adapting to them. The number of operational wavelengths in the new devices grew from several hundred to several thousand, and in subsequent types of radio stations--shortwave types-

even to tens of thousands. The block or module and bulk assembly became the basic design. Semiconductor-diode elements and various types of transistors found considerable application. Fully transistorized equipment also appeared.

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Achievements in the field of semiconductor technology led to the design by military technicians of modern remote control devices for radio stations--wire and wireless, many types of special radio receivers, radio-telephone centrals, etc. Most of them made up communications centers. This led, furthermore, to another qualitative advance; to the undertaking of the subsequent production of a third post-war generation of radio equipment--single band stations. With regard to the permanence and stability of the operation of radio channels, this equipment sometimes used only as terminal devices, was included in the uniform, complex communications system, often making up exclusively information transmission systems, leading to actual terminal devices--teleprinters, telecopiers, telephones, etc.

RADIO LINK TRANSMISSION EQUIPMENT

At the beginning of the 1950's the communications forces were supplied with new types of equipment, more precisely--transmission devices, few and multi-channel radio link stations. Initially, these were relatively large devices, requiring external telephone or telegraph multiplying instruments. Later, this type of multi-channel equipment, also produced in Poland, contained its own multiplying systems. The first device of this group was the R-401 telephone-telegraph few channel radio link station, widely used as a transmission system. It facilitated, as no other device then in use

could, very rapid connection to the full spread wire network or immediate connection with the necessary staff headquarters. This and other newer types of radio link stations already for many years have become the equipment, without which it would be very difficult to imagine securing communications under field conditions.

The equipping of the communications forces with radio link stations has contributed to the effacement of the already mentioned expressed boundary, which existed until recently, between radio and wire systems, and to the erection of a complex communications system. This device has also been used in various types of systems with terminal equipment, allowing their wireless inclusion into the full spread transmission network, commutation or terminal devices.

WIRE TRANSMISSION EQUIPMENT

The great importance of radio and radio link transmission equipment in contemporary communications does not negate the advantages of traditional wire transmission devices, such as various types of communications lines. All of these types of equipment are complementary, and in particular situations each of them plays a role in the communications system. /

At the beginning of the 1950's, after testing cable C in order to cover the shortage of cable, the production of older types of cable, tested in practical operation, was begun. In the following years, multi-pair field cables, Pupin cables and long-distance, accoustical and new telephone cables were also produced. Methods for the maximum utilization of the full spread wire network over its multiplication

were worked out. Line converters were initially used, but the communications forces were later equipped with various types of multipliers. Domestically produced acoustical amplifiers supplemented the entire assortment of this equipment. In a short while, based on this equipment, arose the production of a series of devices found in the framework of standardized communications centers.

COMMUTATION EQUIPMENT

Telephone switchboards, telegraph commutators and telephone-telegraph exchanges comprise the group of commutation equipment. After the first production tests of the LP-10 and LP-30 telephone switchboards, undertaken already at the end of the 1940's, the final years of the 1960's bore new developments, namely 10 digit switchboards with pushbutton call and notification, allowing the operator to execute connection functions. A new type of switchboard, the LP-40, has already been produced. Presently, the modernized LP-10MR and LP-40MR radio-telephone switchboards are appearing in connection with the introduction of new radio stations and their inclusion in the general communications system.

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Significant changes have also been noted in the field of telegraphic equipment. slotted telegraph switchboards and automatic "jumpers" have totally fallen out of use. In their place have been introduced modern telegraph switchboards with manifold connection and exploitation possibilities. A series of communications centrals--both manual and automatic, which secure the connection of both telephone and telegraph users into complex wire-radio networks--has appeared. This also enters into the framework of standardized communications centers. All of the modifications in this field have

been worked out by specialized technicians of the communications forces, and the equipment is produced in Poland.

DATA PROCESSING EQUIPMENT

Modern leadership and management requires the speeding up of the flow and processing of information. This can be achieved by the mechanization and automation of these processes. Electronic computers (EMC), data transmission devices (UTD), computers' input and output devices and information display equipment, called peripheral equipment for short, make up the basic elements of an automated system.

Military electronic computers are divided into field and stationary categories. From the point of view of how they carry out their function, they can be subdivided as:

- specialized EMC, used for example as artillery computers, direction systems and others, computing according to standard programs, equipped in the machine;
- universal EMC, used for data processing according to the prepared program, based on permanent data loaded in its memory (called information banks), and modified data, introduced each time before computation;
- communication EMC, used in automated communications systems;
- miniature EMC, commonly called minicomputers, used for various purposes (such as subscriber equipment for simple computations, and initial data processing);
- automatic machines designated for various purposes in order to automate direction processes. They are simplified, specialized EMC.

The above mentioned computers were designed for military communications and are presently utilized in various command levels. A considerable part of these machines were produced in Poland on the basis of domestic designs.

DATA TRANSMISSION EQUIPMENT

The introduction of data transmission equipment into the army is connected to permanent problems, which can be defined by three words: faster, better and continuous. The use of electronic computers has only caused a significant increase in the need for equipment, especially in the field of the rapid and reliable transfer of information.

A modern EMC can perform hundreds of thousands of arithmetic operations per second. In order to use the computational power of the EMC rationally, it is necessary to increase the flow of information entering the EMC from the data source, as well as that leaving the EMC. This problem becomes especially sharp when the data source or user is located a considerable distance from the EMC. Obviously, the user (the command or staff) is interested in using accurate computations, evaluations and analyses. The accurate transmission of data into the EMC, its processing and illustration on peripheral devices is, therefore, necessary.

Equipment, which facilitates the utilization of communications channels with parameters possessed for the needs of an EMC, is called data transmission equipment (UTD). Its main task is to increase

significantly the speed of transmission and raise the reliability of the transmitted information. The commonly used UTD is characterized by a terminal error level from 10^{-6} to 10^{-10} (with an initial channel error level of 10^{-1} to 10^{-3}).

With regard to modulation speed, UTD can be divided into:

- low speed UTD--50 to 200 bits;
- medium speed UTD--200 to 3000 bits;
- high speed UTD--over 3000 bits.

This division is connected to the channel's width. Low and medium speed devices can be used in channels at normal speeds. Machines with high speed modulation can be used in "wide belt" channels.

Data transmission equipment can also be divided into:

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- equipment with error detection, in which errors are only detected, and the user receives the information as a lack of data;
- equipment with error correction, in which the erroneous signal is eliminated, and in its place the UTD introduces the appropriate one, or corrects the errors arising during transmission.

Equipment with error detection is used in so-called tracking systems (for ex. tracking targets), in which the target's position is given rhythmically, at fixed intervals, and the equipment with error correction--for the needs of the EMC.

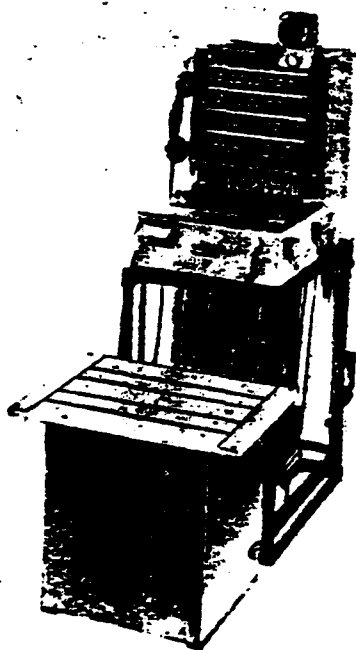
The UTD is divided into simplex and duplex equipment depending upon the type of operation. The simplex UTD, moreover, can be divided into

equipment operating with or without a reverse channel.

The UTD can be adapted for operation in wire and radio link channels (carrying or natural) and in radio channels. Among the group adapted for operation in radio channels, equipment adapted for shortwave operation can be distinguished. The shortwave radio channel is characterized by the highest initial error level and an important level of disturbances.

Presently, much of the equipment mentioned above is used in the communications forces. They are domestically produced.

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The LP-40 MR radio-telephone field switchboard

INPUT AND OUTPUT DEVICES FOR COMPUTERS AND INFORMATION DISPLAY DEVICES

The use of computers demands an entire series of input and output equipment, as well as information display devices. Besides paper tape readers and tape perforators, other peripheral devices are needed to work together with computers. These include alphanumeric printers, screen monitors and graphoscopes, designed together with other electronic computation equipment also necessary for automated systems.

Information zobrawanie equipment, which finds broad application in military automated systems, includes screen monitors with alphanumeric keyboards.

Their production was begun at the onset of the 1970's. The modernity of this equipment is testified to by high character resolution and the silently functioning keyboard.

TELEPHONE TERMINAL EQUIPMENT

As has already been mentioned, by the end of 1957 the entire replacement of communications equipment had been carried out. This also included telephone terminal equipment, whose basic parts are telephones. After the first tests, carried out on Polish telephones, produced in 1948, industry began producing the improved TAI-43 field model, and then modernized it in the form of the TAI-43MR, making remote operation over radio stations possible, with simultaneous

commutation from reception to transmission and back.

Parallel to this, corresponding to the constantly increasing needs of command, many types of telephone speakers and multi-line apparatuses were designed in communications units and industry. These were utilized in various command vehicles. Dispatcher-conferencing equipment was also produced.

TELEGRAPHIC TERMINAL EQUIPMENT

By 1948 the basic telegraphic terminal device had become the teleprinter. The very durable, better working start-stop ST-35 teleprinter ensued. It was used to secure telegraphic communications over parent lines, or multiplied, over radio link channels, and to secure teleprinter communication over radio both by means of the first post-war generation radio station and new radio stations.

The next teleprinters, used for military communications, were the DALIBOR tape and sheet models, with and without automated perforated tape transport, the T tape and sheet models, and the more developed ST model. This model, sometimes difficult to use over radio, especially at long distances, has not caused any difficulties.

TELECOPY TERMINAL EQUIPMENT

Work on the application of telecopiers in military communications was

begun at the end of the 1950's. Specialists of the communications forces dealt with this exclusively. This lasted only a short while, since already at the beginning of the 1960's a model of the TB-1 telecopier had been designed and produced. This made possible the transmission and reception of A5 form documents. The experience gained from this facilitated the design at the end of the 1960's of the new TB-2/P telecopier, whose production was undertaken by Polish industry. This type of apparatus allowed the transmission and reception of A4 form documents, even under difficult field conditions. This device is characterized by greater mechanical durability and can use simultaneously network and its own synchronization with an ultra stable quartz generator.

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COMMUNICATIONS ACCESSORIES AND AUXILIARY EQUIPMENT

A very wide range of different types of devices, measurement instruments, antennae, gauges of individual communications devices, tape recorders, etc., which do not play a direct role in the transmission and reception of information, but comprise a necessary part of the equipment, are considered to be "communications accessories and auxiliary equipment." The historical development of this type of equipment is much too broad a theme to be covered here. It is important, however, to pause a short while in order to mention two matters.

The first is the theoretical designing and subsequent production by the scientific-technical agencies of the communications forces of devices designated for the shortwave probing of the ionosphere. The second is the theoretical designing, construction and subsequent practical application, also by the communications forces, of very

efficient antennae and auxiliary systems, which allowed the securing of permanent shortwave communications, both while moving and in the so-called dead zone.

Communications experts have dealt with the practical problem of the truly efficient utilization of shortwaves for the maintenance of communications over long distances for many years. It has been demonstrated in practice that periodic ionospheric forecasts, on the basis of which frequencies have been allocated to individual radio relations, do not guarantee to a sufficient degree the permanent maintenance of communications. It has been ascertained that this depends, above all, on the existing conditions, propagated in the designated area, and these conditions in most cases escape prognosis. The idea was floated that the optimum frequency for radio operation can be determined by previously performed tests, and was soon transformed into a concrete reality, in equipment, allowing the determination over the course of several minutes of the usefulness of a given frequency for the necessary relation.

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The second matter is closely tied to the first, where it is a question, as mentioned earlier, of securing continuous shortwave radio communications. This concerns the quasi-magnetic antenna. Design-wise, it was produced in the form of an incomplete coil of tubes, joined to space by aid of a magnetic field, from whence comes the name quasi-magnetic--really magnetic. Its dimensions are relatively small and in connection with this, it can be installed on a mechanical vehicle. This antenna is connected to a transmitter's output by means of a special coupler. This antenna is directed with its maximum radiation aimed upward. Thanks to its radiation characteristic, it can be used for communications in the so-called dead zone, even with a relatively low power radio station.

FEED SOURCES AND FEEDING EQUIPMENT

One of the most essential elements, which are decisive for the utilization of communications equipment, beginning with the simplest and ending with the most complicated, are electrical feed sources and all types of feeders. Electrical feed sources, used in military communications equipment, include, above all, electrical cells and dry batteries, silver-zinc, cadmium-nickel and lead batteries, and current-creating systems. The majority of the mentioned feed sources have found application in civilian equipment, which require electrical energy for their functioning.

The domestic production of the mentioned feed sources begun in 1952 has allowed the need of the communications forces for anode dry batteries and electrical cells for telephones to be met. This production was developed systematically, decreasing the imports of these feed sources.

Current-creating equipment includes, above all, special feed stations, battery chargers and portable battery chargers. The production of this equipment was begun in Poland in 1954-55, and feed stations and mobile battery chargers, in 1964. Polish industry usually meets the entire need of the communications forces for these devices.

Modern military communications equipment is characterized by very high technical parameters. The range of its operation is constantly growing, in accordance with the demands of modern tactics and operations, and its possibilities facilitate military command in

various types of field operations. The capacity of individual devices and entire communications systems of various command levels is increasing together with the increased flow of information. Modern equipment can also secure a fixed level of secrecy for that information. The constantly improving possibilities of automated communications systems and their ready functioning are necessary for accurate and rapid decision making. The automation of command processes will follow.

One must not, however, forget the human factor. Only humans can think. Even the most sophisticated machine and electronic systems are not capable of replacing people. Appropriately programmed, consistent with human wishes, they can only ease human labor, executing determined functions more rapidly and precisely. The result of this work depends upon people, upon the qualifications both of the serviceability of the new equipment and of the people who use it. This concerns everyone: the officers, cadets, non-commissioned officers and privates of the communications forces. This also concerns the officers of all levels of command and staff. It is necessary to be aware of the fact that sometimes, with regard to the inaccuracy of the too technically complicated equipment, officers will have to prepare material in the "language" of the machine. Independently of the further development of communications automation, the claim can be ventured that the human role in these circumstances not only will not decrease, but just the opposite--it will increase considerably.

Table 5.6 A general survey of the development of some groups of communications equipment, beginning from 1945

A. radio stations; A1. single channel radio stations with one or two types of emissions (F3, A3 or A1, A3); A2. single channel radio stations with one, two or three types of emissions (F3 or A1, A3 or A1, A3 with the use of mouthpiece--teletype); A3. radio stations with a highly stable frequency network, single or multi-channel, with automatic adaptation systems and with one or several types of emission; A4. radio stations with a highly stable frequency network, wide band, one or two band, with one, several and several tens of types of emission; B. telephones; B1. the MB buzzer telephone system, buzzer-inductor or inductor and CB system; B2. the MB inductor telephone system, various types of CB and CBa systems; B3. as above, the MB/CB inductor telephone system with transistorized amplifiers, radio-telephone inductor, speaker and multi-line, also a series of dispatcher-conferencing devices; C. telegraph and teletype devices; C1. Morse or BDA telegraph devices and the ST-35 teletype; C2. the ST-35 teletype, C3. various types of tape and sheet teleprinters also with automatic information transmission and reception registered on perforated tape; D. communications lines; D1. PTF-7 telephone and PTG-19 fixed and pole overhead lines and wire; D2. PTF-7 telephone, PTG-19 telegraph and C type universal fixed or pole overhead lines, Pupin cables and wire; D3. single and multi-pair long-distance cables, specialized cables and new types of telephone wire; E. multiplying devices; E1. line converter; E2. line converter, TFC and ME-8 telephone and FT-3 telegraph multiplying large tube devices; E3. old and new types of multiplying devices, transistorized and miniaturized devices with a greater multiplication with operator or non-operator controlled telephone amplifiers

| A Radiostacje | B Aparaty telefoniczne | C Aparaty telegraficzne i dalekopisy | D Linie łączności | E Urządzenia zwielokrotniające |
|---|--|---|--|--|
| <p>1. Radiostacje jednokanałowe z jednym lub dwoma rodzajami emisji (F3 lub A3 lub A1, A3).</p> <p>2. Radiostacje jednokanałowe z jednym, dwoma lub trzema rodzajami emisji (F3 lub A1, A3 lub A1, A3 z zastosowaniem przystawki — praca dalekopisowa).</p> <p>3. Radiostacje z wysokostabilną siatką częstotliwości, jedno- i wielokanałowe, z układami automatycznego dostrajania oraz z jednym i kilkoma rodzajami emisji.</p> <p>4. Radiostacje z wysokostabilną siatką częstotliwości, szerokopasmowe, jedno- i dwuwstęgowe, z jedną, kilkoma i kilkunastoma rodzajami emisji.</p> | <p>1. Aparaty telefoniczne systemu MB brzęczykowe, brzęczykowo-induktorowe i induktorowe oraz systemu CB.</p> <p>2. Aparaty telefoniczne systemu MB induktorowe, różnego rodzaju aparaty systemu CB i CBa.</p> <p>3. Jak wyżej oraz telefoniczne aparaty induktorowe systemu MB/CB ze wzmacniaczami tranzystorowymi, induktorowe radiowo-telefoniczne, głośnikowe i wieloliniowe, a także szereg urządzeń dyspozytorsko-konferencyjnych.</p> | <p>1. Aparaty telegraficzne Morse'a i BDA oraz dalekopisy ST-35.</p> <p>2. Dalekopisy ST-35</p> <p>3. Różnych odmian dalekopisy taśmowe i arkuszowe, również z automatyką przekazywania i odbioru informacji zarejestrowanych na taśmach dziurkowanych.</p> | <p>1. Linie napowietrzne stałe i tyczkowe oraz przewody telefoniczne PTF-7 i telegraficzne PTG-19.</p> <p>2. Linie napowietrzne stałe i tyczkowe, kabel pupinizowany, przewody telefoniczne PTF-7 i telegraficzne PTG-19 oraz uniwersalne typu C.</p> <p>3. Jedno- i wieloparowe kable dalekosiężne, kable specjalizowane i nowe odmiany przewodów telefonicznych.</p> | <p>1. Przenośniki liniowe.</p> <p>2. Przenośniki liniowe, duże lampowe urządzenia zwielokrotniające telefoniczne TFC i ME-8 oraz telegraficzne — FT-3.</p> <p>3. Urządzenia zwielokrotniające poprzednich typów oraz nowoczesne, tranzystorowane i miniaturyzowane urządzenia o dużej krotności zwielokrotnienia ze wzmacniakami obsługiwanymi i nieobsługiwanymi.</p> |

6. ENGINEERING--SAPPER EQUIPMENT

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6.1. TEMPORARY TRANSIT--BRIDGE EQUIPMENT

The organization of transit composed and still does one of the main tasks of military engineers. This field has noted the greatest accomplishments, both in methods for the organization of labor and in the modernization of technical equipment. Modern optical-measuring instruments are used today for studying water obstacles: devices with great magnifying ability, nighttime vision, range finders, theodolites, mechanical profilometers, pressure profilographs, instruments for detecting all types of possible obstacles for application on shore and underwater--new depth detectors, frogman communications gear with devices facilitating wireless communications underwater on with the shore, navigational equipment, for example scouting boats, etc.

Pontoon devices used for ferriage and bridge devices have undergone significant evolution during the last thirty years. During World War II open pontoons were used for ferriage and bridges. These were often rendered useless by flooding when overloaded, when struck by waves and nearby explosions. Wood pontoons enjoyed the broadest application and then came metal ones or plywood (folding) and board (stiff) boats.

In the post-war period, production of light pontoons was begun, first of wood (DLP from plywood) and then of LPP metal ones, carried on specially adapted motor vehicles. From these pieces ferriage could be built for all types of military loads excepting tanks. At the same time production was begun of heavy, metal, hermetically sealed

pontoons, which could be used to build bridges for all types of military loads.

In the course of the modernization of hermetic pontoons, water proof bulkheads were introduced; that is, the pontoon was reshaped into a multichambered buoy. It was, consequently, quite bullet proof and resistant to mechanical damaging. The design of TPP type pontoons was toughened and basic load structure elements were mounted on the pontoons. This allowed the elimination of very arduous human labor (the carrying of beams) and speeded up the assembly of bridges. Fabricated mooring elements were also introduced, facilitating and speeding up the construction of moors. The results of the ideas of numerous inventors also led to the introduction of many improvements. Finally, there existed the possibility of using moorless bridges, which not only speeded up and eased the organization of transit, but also facilitated its execution on a broad front, at any location.

Pontoon bridges provided the best way to cross water obstacles. They are especially important for crossing contaminated terrain.

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Progress in the field of pontoon bridges depends on many factors, of which the most important are: the increase of the load capacity tied to the increase of the weight of military vehicles, the acceleration of construction tempo and damage resistance, that is, the preservation of usage life under the very complicated conditions of modern warfare. Not only the technical perfection of equipment, but also the scientific designing of labor organization methods and the amending of training contribute to the meeting of these demands.

Finally, military engineers were equipped with a new, technically and

design-wise improved pontoon system with a permanent structure. The roadway was built directly into the pontoon, thus eliminating arduous and protracted human labor. This pontoon system was designated for ferriage and transit bridges.

For example, the PP-64 pontoon system is characterized by:

- the ability simultaneously to play the role of floating support, load structure and drive part;
- the basic assembly and transport unit is a pontoon block comprised of two floating pontoons;
- the permanent mooring function in transit ferriages and that of the shore parts in pontoon bridges are performed by shore blocks;
- the design of the floating and shore pontoons allow their mooring on the water obstacle's floor;
- the assembly designs of the ferriage and floating bridges are to a great extent very similar and simplified;
- the floating equipment is unloaded directly onto the water or mechanically loaded onto a specially adapted STAR-660 motor vehicle.

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The KH-200 tow cruiser is part of the PP-64 pontoon system. This type of cruiser is used to scout water obstacles, push or tow equipment, convey temporary transit bridges, push or tow transport ferries to the temporary transit ferriage and execute auxiliary tasks on the water.

The KH-200 is a single-screw river towing-pushing vessel. It is manufactured from steel sheet. The cruiser is propelled by a six-cylinder, four-valve, high-pressure engine with direct fuel injection. The engine propels over a reverse-reducer and drive shaft the screw propeller functioning in a Kort adjutage. The cruiser and the reverse-reducer are controlled from the cruiser point by aid of a lever. The engine has a closed cooling system, which exchanges heat

through a Kort adjutage. The cruiser is steered by an automobile-type steering wheel over a line system, connected with a steering sector in the stern, which drives two displacement rudders.

A very important problem is the ability to surmount a thick network of small water obstacles: narrow canals, streams, drainage ditches. SMT concurrent bridges with floating supports, loaded on the STAR-600 motor vehicle, are commonly used for this.

The SMT-1 concurrent bridge mounted on a STAR-660 motor vehicle serves to overcome natural and artificial open land obstacles. In the bridge system is included a specially adapted motor vehicle, bridge spans and equipment for the removal of bridge obstacles. SMT-1 bridge spans with supports can be used for the construction of multi-span, shallow water bridges (two and three span).

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LPD light portable roads, which secure the passage of all vehicles weighing up to 20 T, are used for all types of transit over difficult terrain and to facilitate the crossing of difficult road sections.

A basic part of the portable road is a rippled steel sheet with a trapezoidal profile, built into a stiffened framework. On this framework are found latches. These serve to connect the sheets together. A two-lane road is built from the sheets on the bed of shallow rivers and streams, over which the crossing of a determined number of vehicles would be very difficult or impossible. Dust, dusty sand, small grain sand, loose clay, peat, peat soils, wet grasses, arable land and other loose sections of terrain are suitable surfaces depending upon the level of moisture and compactness. The sheets can be arranged in a straight line or in a curve. LPD sheets can also be used for the assembly of channels and trench crossings.

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Landing transit depends on the mounting of military equipment in multichambered, pneumatic LD landing boats, amphibious tractored transports and self-propelled tractored ferries, which allow the transit of all types of military vehicles. The abbreviated data concerning transit systems cited below facilitate an orientation in the present state of military engineering equipment in the Polish Army in this particular field.

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The LR scouting boat is made of steelon, rubberized fabric with four separate compartments, which prevent its sinking if punctured. The boat can be propelled by oars or an outboard motor.

The LR's basic technical data is:

| | |
|----------------------------------|--------|
| load capacity | 450 kG |
| total displacement | 950 kG |
| inflation time with the A-3 pump | 8 min |

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The LD landing boat is made of plastic. The body's design makes the boat unsinkable. It can be propelled by oars or by an outboard motor. The body's special shape and the sides' rigidity allow the boat to be used as a floating support for light transit ferries used for auxiliary functions in water. 4-5 boats can be transported on the STAR-66 motor vehicle, stacked vertically.

The LD's basic technical data is:

| | |
|---|---------------------------------|
| weight with permanent equipment | 300 kG |
| weight with complete equipment | 350 kG |
| carrying capacity | 15 soldiers--altogether 1500 kG |
| the boat's greatest outside load allowable as a rescue system | up to 2.5 T |

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1

total displacement

5.3 T

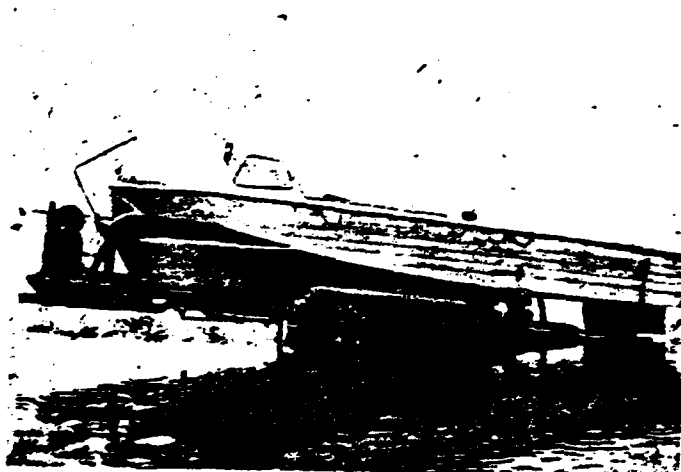
DE-6, DE-25 and DE-45 outboard motors can be used to propel scouting and landing boats. They are characterized by high technical parameters, modern design, relatively small dimensions, great power, light weight and miserly fuel consumption.

The DE-6 outboard motor is designated, above all, for the propulsion of the LR scouting boat. This is a single-cylinder, bi-valve motor with a vertical revolution axis. It is cooled directly by the outside water. It can operate in reverse with its revolutions around a vertical axis of 180°.

Life jackets serve to prevent soldiers from drowning. All soldiers of the engineering forces, performing their duties in water, are equipped with them. Two type of life jackets are included in the equipment of the engineering forces: the KRK kapok-filled and KRP pneumatic life jackets.

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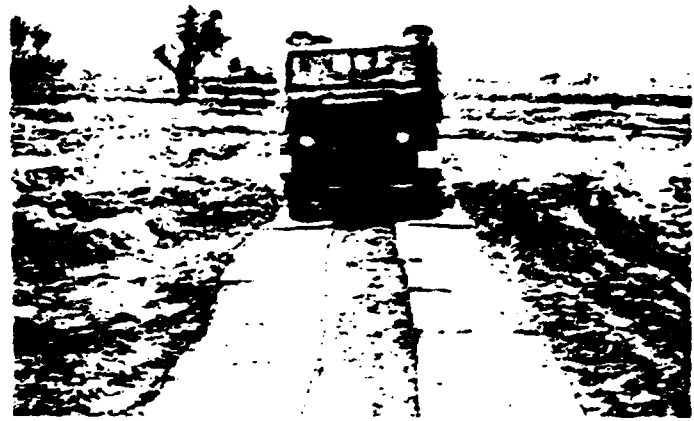
the KH-200 towing cruiser



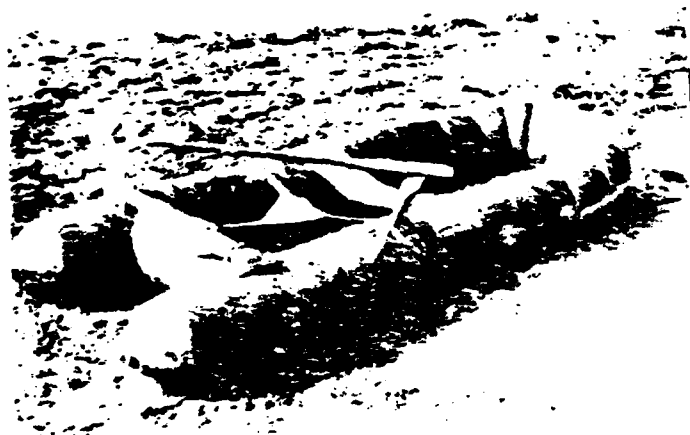
the SMT-1 ncurrent bridge
with PSMT-2 supports



the PP-64 pontoon bridge system



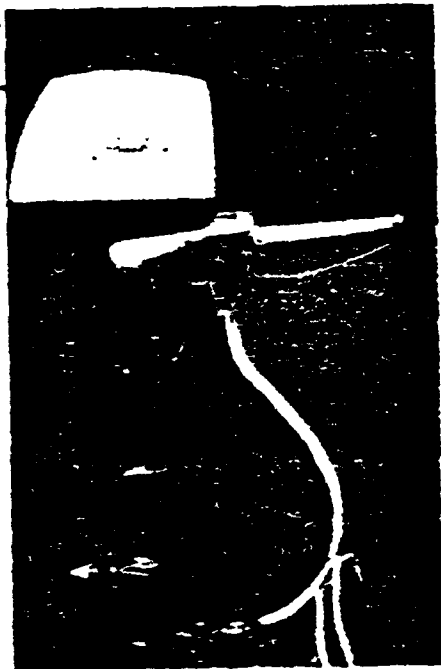
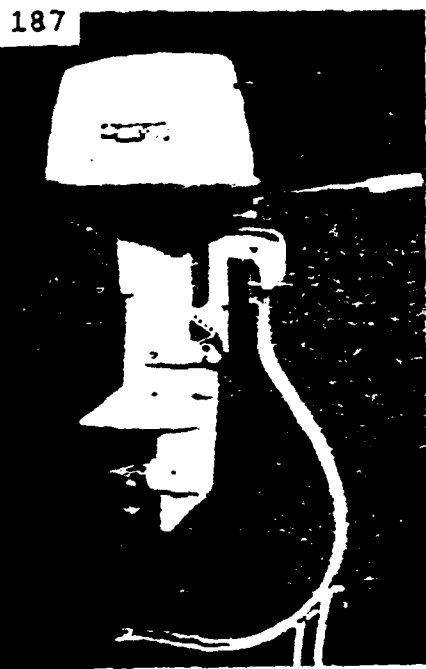
the LPD light portable road



the LR scouting boat



the LD landing boat



the KRK life jacket

In connection with the growth of destructive systems of warfare, all types of military forces place great value on the preservation of their own personnel. They carry out, consequently, operations connected with the fortification of open land, earthworks, camouflage, etc. The defensive properties of trenches have not lost their importance; only the means allowing the rapid performance of work have been improved. Our forces possess not only shovels, axes and manual saws, but also other implements, such as systems for the concealment of explosive devices, bulldozer accessories for battlefield vehicles and tractors, trench digging devices (rotary and other excavators, trench plows), general terrain altering machines (excavators, bulldozers, scrapers, graders etc.), and wood working machines (combustion and electrical types).

The mechanization of engineering operations has achieved significant progress. However, the weight of the machines involved and their large dimensions have forced designs to be improved. This has been reflected in the production in Poland of machines propelled by the most modern high-pressure engines.

Open trenches are usually not sufficient. People and equipment need to be protected from napalm, heat and penetrative radiation, radioactive dust and shock wave blasts. It is necessary, therefore to cover the trenches and to construct safer protection for personnel and battlefield equipment.

In the post-war years, equipment for the mechanization of engineering operations, which secured the possibility of performing such activity

during the war, has become unacceptable under new conditions, that is in a situation anticipating the use of nuclear missiles.

Under such conditions, both the quality and the quantity of engineering equipment for the mechanization of operations possessed by the engineering forces would not be able to meet the tasks.

This state of affairs lasted until 1952. Then, domestic industry 170 undertook efforts aimed at beginning the production of the simplest equipment, and in 1953--the first complicated equipment and machines, both according to licensed documentation (the RMK-3 drop-hammer, the LRM-79 frame-saw) and domestic designs (the GKT-60 frame-saw). The number of devices found in the equipment of the engineering forces increased every year.

In the first post-war years, the engineering forces did not possess earthworks machines. These machines were introduced only in later years, that is in proportion to the growth in importance of engineering operations in connection to the need for the rapid concealment of personnel and battlefield equipment from the enemy's destructive systems.

As the years passed the equipment for the mechanization of engineering operations was modernized. Together with the modernization of old equipment, new types of machines and devices with greater effectiveness and better exploitation value were produced. Earthworks machines in the next period replaced simple manual implements and tools. Attachable machines (graders, scrapers) were replaced by self-propelled machines, which were quite maneuverable and independent of tractors. The new machines, independent of the

fact that they had their own propulsion, were equipped with two and even three auxiliary devices, allowing, depending upon the need, grading, bulldozing or scarifying.

Since machines mounted on tracked chassis had limited mobility, the army engineers were equipped with a certain number of wheel mounted machines, characterized by greater maneuverability and mobility. This was especially true for excavators, whose digging power was not dependent upon the attachment's power to the degree that, for example, bulldozers were.

The next stage in the modernization of the equipment for the mechanization of engineering operations was the introduction of electrical, electrical-hydraulic and hydraulic systems instead of mechanical systems for machine and implement propulsion and steering.

The rapid growth in the amount of earthworks, connected to the concealment of personnel and battlefield equipment, influenced the designing of more efficient earthworks machines, realized thanks to the use of new earthworking and soil removal methods. The MDK-2M is an example of such a machine.

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Independent of the equipping of the engineering forces with very efficient and rapid working machines, bulldozing attachments for tractors and tanks were also produced and introduced.

Such developments allowed the army engineers to concentrate their efforts in the most difficult parts of their operations connected to battlefield engineering, at the same time providing armored and

mechanized forces the possibility of rapidly concealing their equipment and personnel in every situation and circumstance. This is one of the basic and important undertakings aimed at making forces autonomous in a determined area in the sphere of battlefield engineering.

Today, we possess a broad assortment of modern, very effective equipment in quantities which can secure the execution of all types of operations in the field of battlefield engineering. It must be pointed out that the amount of earthworks tied to the construction of tactical defenses, anticipated by regulations valid for the 1940's and the beginning of the 1950's can today be constructed four times faster. This comparison best demonstrates the technical progress made in the field of equipment for the mechanization of engineering operations in the thirty years of the Polish Army's existence.

The KS-251 self-propelled excavator is designated for the mechanization of earthworks construction and for loading and unloading. The excavator is composed of three basic parts: the body, the chassis and interchangeable auxiliary devices. These are: push-shovels, undershots and undershots for deep excavations, graders, claws and hoists.

The USCz-55 bulldozing accessory serves for the construction of trenches and of passages through anti-armor obstacles. It is connected to the front of a tank. It consists of: a blade, pushing frame, upper hoist, electro-hydraulic system and elements for its attachment to the tank.

Both quantitative and qualitative changes have been made in the group

of mechanical accessories connected to the building of bridges and fortifications.

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Such typical and basic military equipment for sappers, as manual saws and carpenter's hatchets, were replaced by mechanical saws (gas or electric), heavy and medium frame saws and electrically driven tools for wood and metal working, powered by electrical power plants. Significant progress can also be noted in the field of mechanical devices and electrical tools. The development of these machines and tools led to the simplification of design, the improvement of usage, the elevation of the safety level and the decrease of weight, with the simultaneous increase in efficiency and usage life. If, for example, the first gas driven saws weighed over 30 kG, and required two individuals to operate them, today's electric saws weigh around 10 kG and are easily operated by one soldier with the same efficiency.

Further progress in this area has occurred in the improvement of machine accessories. These allow basic machines to be used for various operations. For example, the above mentioned saw can be used for boring into the ground, cutting into ice and cutting piles under water. The accessories are easy to change and can, therefore, be used rapidly in the field.

The BK-3a saw with the OBK-3a/L accessory for cutting into ice, the OBK-3a/P accessory for cutting piles under water and the OBK-3a/W drill accessory is designated to cut through ice sheets up to 350 mm thick, to cut submerged piles during the underwater construction of wooden bridge supports and to make openings in the frozen ground and ice for explosive charges.

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The GKTs-60 frame-saw is used to cut timber into pieces, logs and planks. The basic frame-saw unit is made up of a cutting table, crank mechanism, saw frame, feed mechanism, transport device, power mechanism and replaceable parts.

In the field of bridge support construction tools, the traditional "baba" [old woman] has been replaced by the pile-driver with a gas-powered maul and the driverless gas-powered maul. The time necessary to build bridges depends to a significant degree on the time necessary to build supports. Therefore, individual driverless mauls are connected to battery pile-driving equipment.

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The NBWP battery pile-driving device is used for the mechanized construction of supports in bodies of water. They make possible the simultaneous driving of four piles into consecutive supports and the reconstruction of old supports. This system includes four TPP (TMP) pontoon systems upon which is mounted the pile-driving and support reconstruction device. The pile-driving device is composed of four pile-drivers with mauls, four double-barreled hoists and a return device, which serves to return the pile-driving device from the working position to the transport position.

Electrical power plants and air-compressors supply the necessary energy for bridge and fortification construction. The processing and preparation sites of materials and elements are illuminated by electric lights. Both electric power plants with electrical units and air-compressors with pneumatic units are characterized by their light weight, ease of use and high level of automation. The electrical lighting system is characterized by similar qualities. The electrical lighting system has standardized accessories, which

allow its installation, necessary for the illumination of objects, for which it is designated.

Such electrical power plants as the IES-16 are designated to feed woodworking tools and machines, for welding, for the drilling of openings in frozen ground, for the crushing of rock and concrete, etc. Moreover, the current producing unit included in this power plant can be used for the feed of various electrical engines, lighting accessories and special devices. The electric power plant is composed of an electrical energy source, a combustion-electrical unit, an electrical drive device, lighting and network accessories, auxiliary equipment, case and cover.

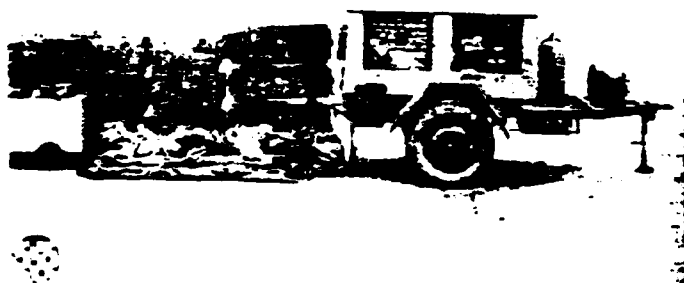
p.192

Table 6.1 The growth of engineering equipment starting from 1945
1. excavators, 2. bulldozers, 3. pile-drivers, 4. frame-saws, 5. electric lighting units, 6. electric power plants, 7. gas-driven saws, 8. mobile repair stations, 9. number, 10. type of equipment, 11. growth coefficient in years

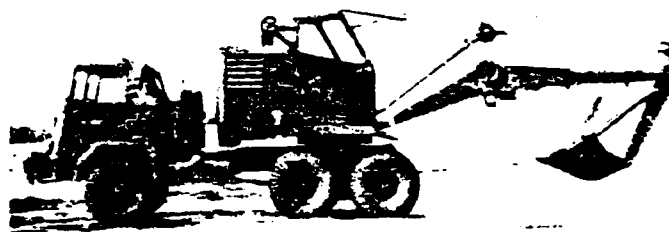
| Lp. | Rodzaj sprzętu | Współczynnik wzrostu w latach | | | | |
|-----|-------------------------------|-------------------------------|------|-------|-------|-------|
| | | 1945 | 1949 | 1955 | 1960 | 1970 |
| 1 | Koparki | — | — | 1 | 6,4 | 39,6 |
| 2 | Spycharki | — | — | 1 | 4,78 | 24,46 |
| 3 | Kafary | 1 | 3,41 | 18,75 | 21,75 | 17,35 |
| 4 | Traki | 1 | 6,33 | 31,33 | 26,50 | 50,16 |
| 5 | Elektrownie oświetleniowe | 1 | 2,5 | 3,61 | 56,15 | 89,00 |
| 6 | Elektrownie siłowe | 1 | 4,5 | 10,66 | 10,66 | 37,03 |
| 7 | Piły spalinowe | 1 | 3,23 | 10,81 | 11,26 | 49,80 |
| 8 | Warsztaty naprawcze (ruchome) | 1 | 9,0 | 9,0 | 118,0 | 150,0 |

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The IES-16 electric power plant



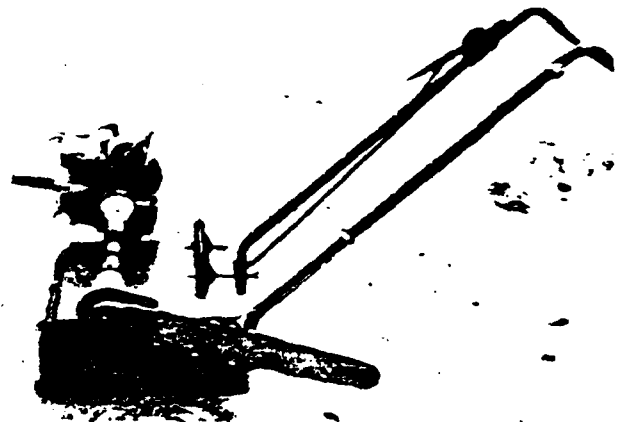
The motorized KS-251 excavator

Table 6.2 The basic technical data for electrical lighting systems
 1. specifications, 2. system type, 3. type of combustion-electrical
 unit, 4. unit power (kW), 5. voltage (V), 6. frequency (Hz), 7. unit weight
 (kg), 8. total weight (kg), 9. number of wood cases (pieces), 10. number of
 canvas covers (pieces), 11. number of illumination points (pieces)

| Wyszczególnienie | Typ elektrowni | | | |
|---|----------------|-------------|-------------|--------------|
| | EO-1 | EO-4 | EO-8 | EO-16 |
| 3 Typ zespołu spalinowo-elektrycznego | GAB-1-1/225 | PAB-4-1/230 | PAD-3-3/400 | PAD-16-3/400 |
| 4 Moc zespołu (KW) | 1 | 4 | 8 | 16 |
| 5 Napięcie (V) | 225 | 230 | 400/230 | 400/230 |
| 6 Częstotliwość (Hz) | 50 | 50 | 50 | 50 |
| 7 Masa zespołu (kg) | 70 | 590 | 1300 | 2400 |
| 8 Masa całkowita osprzętu (kg) | 400 | 900 | 1850 | 2780 |
| 9 Liczba skrzyń drewnianych (szt.) | 4 | 7 | 12 | 18 |
| 10 Liczba pokrowców brezentowych (szt.) | 6 | 12 | 28 | 43 |
| 11 Liczba punktów świetlnych (szt.) | 12 | 64 | 96 | 144 |



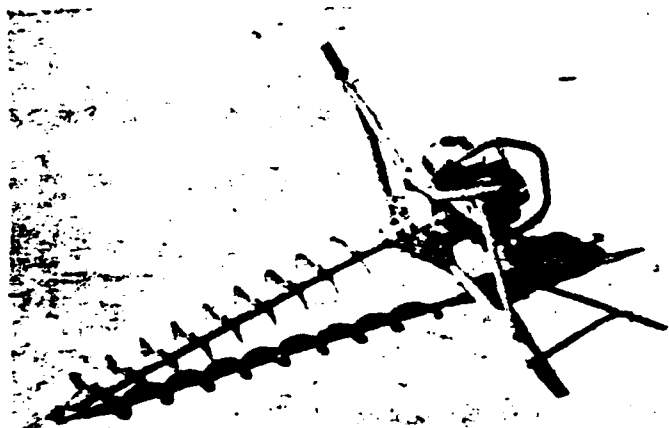
The USCz-55 bulldozer



The BK-3a gas-driven saw with
the OBK-3a/L ice cutting accessory

The BK-3A gas-driven saw with
the OBK-3W drill accessory

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The UBWP battery pile-driver

Terrain fortification is one of the more important elements of battlefield engineering. Its goals are:

- to secure the survival and preservation of the fighting abilities of personnel and equipment under conditions of the usage of modern methods of destruction;
- to secure the continuity of command and protect resting forces;
- to protect material and supplies located in field storage bases. 196

In order to meet this important task and to shorten the time necessary for the construction of fortifications, a series of standardized, storage designs, designated for the rapid construction of shelters, has been worked out over the last thirty years.

The shelters also protect against penetrative radiation.

In the field of camouflage progress has been marked by the successful elimination of previously used screens made of cotton and silk and replaced by screens made of modern plastics. In recent years basic types of plastic screens made of PCV (dyed in mass with protective colors) and of polyamides have been produced and delivered to the army.

The materials used are practically non-combustible and are characterized by a great resistance to the effect of atmospheric and biological factors.

6.4 MILITARY WATER SUPPLY EQUIPMENT

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The supplying of an army with water of normative quality and in amounts sufficient to meet everyday needs, in order to maintain complete physical and fighting efficiency, is a very important problem in modern warfare. The development of weapons of mass destruction, having created the conditions for the complete contamination of drinking water with radioactive or biological substances or battlefield poisons, has intensified the consideration of this problem.

In World War II an army could still directly utilize sources of potable water, which contained, at most, only natural or limited pollution--pathogenic organisms, which were not as dangerous for living organisms as contaminated or poisoned water. Usually, water fit for use must be produced. The proper choice of technology for water purification, which is serviceable and efficient under field conditions, is tied to this process.

From the moment of the Polish Army's inception the entire matter connected to the supply of the army with water was delegated to sapper subdivisions, provided with the same equipment then used in the Soviet Army. This equipment included:

- the ZB-140 ground hand-drill for the drilling of test holes in soft soil up to a depth of 10 m;
- the MTK small tubular well drilling system with hand pump with an output capacity of 15-20 l/min, used for obtaining water from water bearing layers up to a depth of 10 m;
- the GTK deep tubular well drilling system with hand pump with an output capacity of up to 30 l/min, used for obtaining water from water bearing layers up to a depth of 30 m;

-- the AWM-3/100 rotary drilling aggregate mounted on a motor vehicle and used for the construction of tubular wells and obtaining of water from water bearing layers up to a depth of 100 m;
--the JaLW scoop-band water lift, propelled manually or mechanically, allowing the vertical removal of water from shaft wells up to a depth of 25 m, with an output capacity of 100 l/min;
--the KF-2 and KF-4 piston hand pumps for moving water from shaft wells up to 6 m deep, with an output capacity of 20-60 l/min;
--a motorized pump with an output capacity of 600 l/min, used for the removal of water from open tanks and its pumping over distances of up to 200m;
--the UNF-30 portable universal filter with an output capacity of 30 l/h, the TUF-200 fabric-carbon filter with an output capacity of 200-400 l/h and the AFS-5000 vehicular filtration station with an output capacity of 2500-5000 l/h, used to purify water of natural pollutants;
--water storage and transport equipment: the 12.5 l capacity rubber knapsack, the 100 l capacity pouch-tank, 1000 and 6000 l capacity rubber storage tanks and 1200 l capacity metal tank-cisterns, mounted on the ZIS-5 motor vehicle.

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The 1950's saw the beginning of the domestic production of equipment (scoops, the MTK tubular well) for the supply of water of a normative quality, purified to acceptable limits of natural and planned contaminants. This equipment can meet in every battlefield situation the growing military water supply needs.

The modernization of existing equipment and the design of new types of equipment have been carried out in this direction. The new SR-7 tubular well with hand pump with an output capacity of 40 l/min was produced in Poland based on the MTK well. It is used throughout the army. Also, the FSW-8000 filter with an output capacity of 4000-8000 l/min was produced on the basis of vehicular filtration systems. Its

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production was begun based on domestic elements and units, as well as on domestic absorption and chemical materials, necessary in the technological processes of water purification.

The FSW-8000 vehicular filtration system for water purification, completely adapted to modern warfare conditions, is used for the field purification of surface and subterranean water of natural and other contaminants (ABC pollutants) and for the testing of the composition and quality of the water, both before and after its purification.

The FSW-8000 filtration system includes such basic elements as: filtration instruments mounted on the STAR-66 motor vehicle, water tanks, motorized pumps, a laboratory for the analysis and determination of water quality, absorption and chemical materials and a double axle trailer.

The water is purified according to two basic purification schemas: the common and special ones, used depending upon the type and concentration of the contaminants.

Well-drilling systems. From the beginning of the 1970's, based on experience and the demands of contemporary warfare, various types of well-drilling systems have been designed, used for the drilling of wells in various hydrogeological conditions. These systems can be used also for exploration, geological, fortification and barrier construction efforts.

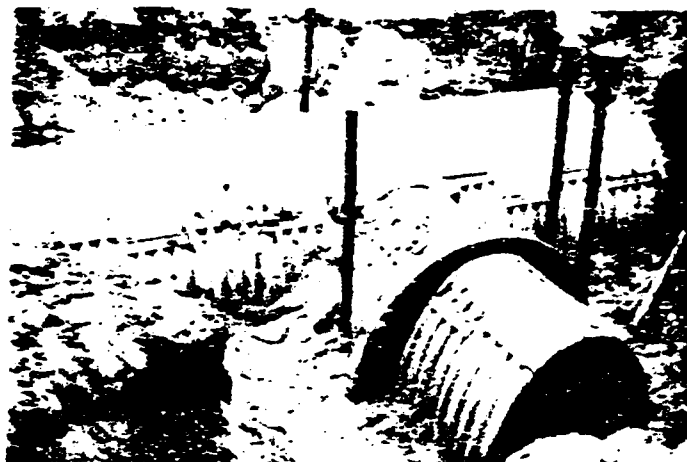
In general, well-drilling systems consist of drilling units--self-propelled drills with drill attachments and well units--bore, tubular and shaft wells.

and shaft wells.

p. 1

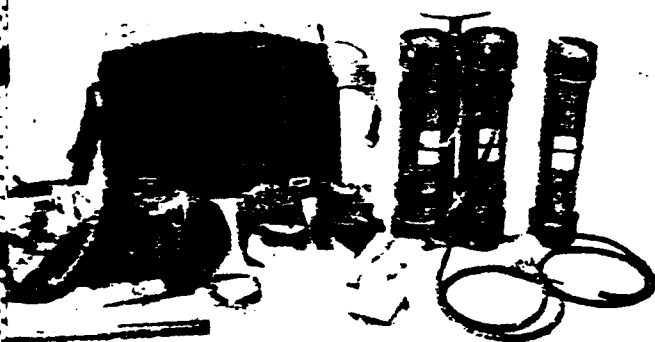


The SBF-180 shelter made of corrugated sheet metal



The SBF-220 shelter made of corrugated sheet metal

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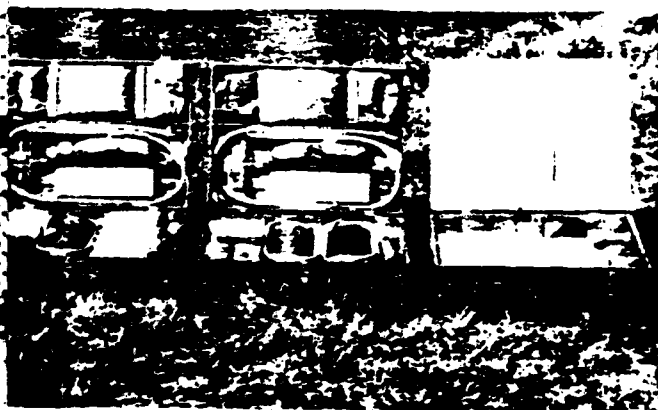


The FPW-30 portable purification filter



The FPW-30 filter readied for water purification

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The FPW-300 portable water purification system in three parts

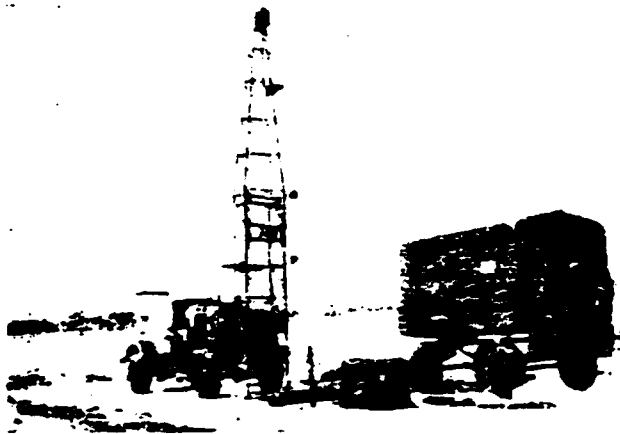


The FPW-300 readied for the special purification of water

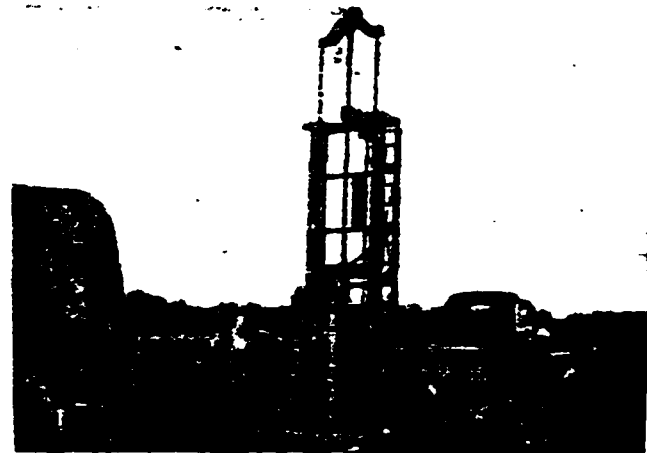
The basic technical data of some systems

1. type of system, 2. type of drill, 3. drilling depth, 4. type of well construction, 5. maximum depth of bore and tubular well, 6. maximum depth of shaft well, 7. time required for the construction of bore wells, 8. time required for the construction of tubular wells, 9. time required for the construction of shaft wells, 10. pump output capacity, 11. operating crew, 12. bore, 13. tubular, 14. tubular, 15. bore, 16. shaft, 17. persons

| | | |
|---|-------------------------|----------------------------------|
| 1 Typ zestawu | ZSW-40 | ZSW-50 |
| 2 Typ wiertnicy | UGB-50 | PBU-50 |
| 3 Głębokość wiercenia | 50 m | 50 m |
| 4 Rodzaj budowanych studni | wwiercana, rurowa | rurowa, wwiercana, szybowa |
| 5 Maksymalna głębokość studni wwiercanej i rurowej | 40 m | 50 m |
| 6 Maksymalna głębokość studni szybowej | — | 15 m |
| 7 Czas budowy studni wwiercanej | 6—9 h | 4—6 h |
| 8 Czas budowy studni rurowej | 15—18 h | 12—15 h |
| 9 Czas budowy studni szybowej | — | 15—20 h |
| 10 Wydajność pompy | 3,6—6 m ³ /h | 3,6—6 m ³ /h |
| 11 Obsługa | 4 osoby | 4 osoby |



The ZSW-40 well-drilling system



The ZSW-50 well-drilling system

6.5 SAPPER-BARRIER EQUIPMENT AND SYSTEMS

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Two periods can be distinguished in the development of sapper-barrier equipment and systems: the wartime and post-war periods, when our needs for such equipment were completely covered by the Soviet Union, and the period of the Polish design and production of this equipment. The later period dates from the 1950's.

In the first period the main stress was placed on the laying of mines and the construction of mine barriers as one of the basic, effective anti-tank and anti-personnel systems. All of the sapper equipment of that period were characterized by simplicity of design and great operational efficiency. They guaranteed the maximum security during usage.

At the beginning of the 1950's Polish industry undertook and mastered the production of anti-armor, anti-personnel and special mines, incendiary and explosive materials. The continuous growth of the requirements of modern warfare forced domestic industry to undertake developmental work in this field, which, besides sapper equipment, included mine detection and removal devices. As a result of this, versatile, new types of mines, used for various tasks, cumulative and timed charges, plastic explosives and fuses were designed, tested and introduced into the army's arsenal.

The W-2-P, W-3-P and W-4-P manual detectors, constructed by our designers and serially produced by Polish industry, became the basic mine detection equipment. These detectors could be used on land and at sea.

The W-2-P mine detector serves for the detection of metallic and non-metallic mines with metallic fuses, found beneath soil or snow, and in rivers or lakes. The detection system is comprised of the detector, a cover, four rods, an antenna prong and two batteries.

The W-4-P mine detector serves for the detection of metallic mines, artillery shells, air bombs, etc., found at great depths beneath soil or snow. It also serves for the detection by frogmen of metallic mines, bombs and shells in rivers or lakes at depths of up to 20 m.

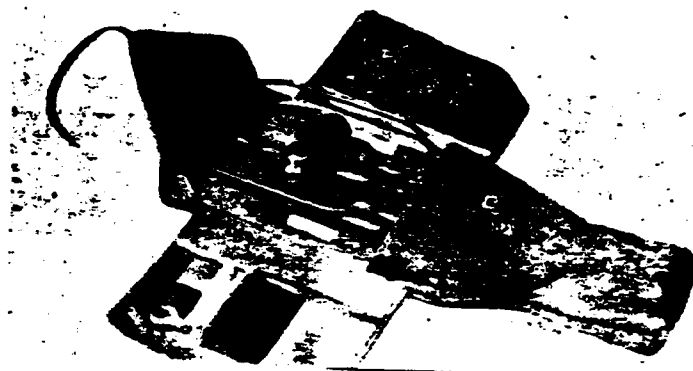
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Engineering forces also possess many other efficient devices, designed by our specialists and produced by Polish industry. A significant part of this equipment is very similar with regard to design and function to that used in the national economy. Engineering-sapper equipment is characterized by the fact that it is entirely suited for both purely military and civilian usage. Transit equipment, bridges, earthworks and construction machinery and explosives are often used in ice and flood control activities, in various rescue missions, in construction, etc.

New equipment, which the military engineers possess, is not only the best suited for defensive purposes, but also increases civilian labor in areas undertaken by engineering forces.

The W-4-P mine detector

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7. EQUIPMENT FOR THE DETECTION, DEFENSE AND LIQUIDATION OF THE EFFECTS OF THE USE OF WEAPONS OF MASS DESTRUCTION

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7.1 A SHORT HISTORY

The traditional tasks of chemical forces, worked out on the basis of experiences from World War I, are tied to battlefield chemical weapons, whose tactical-technical and toxic properties did not make them forces which were decisive on the battlefield. Nor was their usage decisive on the operational scale. At the end of the interwar period, the German scientist, Schroeder, working on the synthesis of plant defense mechanisms, discovered a group of chemical compounds with unusually powerful toxic properties, which affected the human nervous system. This discovery was used during World War II by the Hitlerite Germans in the production of artillery ammunition and bombs, filled with these highly toxic substances. Certainly, the German preparation for chemical warfare did not remain without a response from the anti-Hitler coalition. This was embodied in the undertaking of intensive work on new toxic substances and on defensive systems. Certainly because of this, the Germans, although preparing for chemical warfare, did not resort to it. After World War II intensive research on new toxic compounds continued. New weapons made from the group of phosphororganic compounds, such as sarin, soman, the so-called nerve gases, which are hundreds of times more toxic than yperite, entered into the arsenal of battlefield poisons (BST). At the end of 1950's the BST arsenal was enlarged by a group of compounds called V gases, especially effective in their effect on the skin. In the military laboratories of the capitalist states, research was carried out on the possibility of the use of poisons, toxins, psychotropic compounds and bacteria, and imperialist doctrinarians developed the tactical and strategic principles for their use. Together with the development of battlefield poisons and

their delivery systems, the modern conception of the tasks in the field of detection, defense and liquidation of contaminants, and consequently of the chemical forces, was worked out.

The new qualitative stage in the field of the tasks and the operational forms of the chemical forces dates from the moment of the detonation of the first atomic bomb. The appearance of this new type of weapon with hitherto unparalleled force and the diversity of destructive systems provoked the reaction of both political and military factors. The quest for the technical means and the organizational forms in order to counteract the effects of the use of the atomic bomb, while still meeting the obligations and tasks stemming from the growing threat of chemical weapons, was entrusted to the chemical forces. Consequently, nuclear arms, and especially radioactive contamination, as well as the growing threat of chemical weapons, became the external factors which determined the direction of activity in the technical field of the chemical forces and provided the dynamism in their development.

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The development of the chemical forces and their technical equipment can be divided into three periods.

The first period began with the origin of the Polish People's Armed Forces in the Soviet Union. It was characterized by the fact that we were indebted to the help of the Soviet Union for its command cadres, equipment and training methods. The technical-training level and technical divisions of the chemical forces of the regenerated Polish Army responded in full to contemporary needs. The activity of the chemical forces in the first post-war years consisted of special courses in which the basic officer and NCO corps were trained. Equipment supply, because of the destruction of domestic industry,

continued to rely on deliveries from the USSR.

The second period in the development of the chemical forces began at the start of the 1950's and was characterized by the growth of qualified technical officer cadres, which were trained in every Polish university, and by the undertaking by Polish industry of the production of some types of chemical military equipment based on licensed documentation received from the USSR. For example, during this period the production of gas masks, ponchos, protective clothing and some decontamination devices was begun. The production of the technical equipment of the chemical forces became bolder and more efficient as Polish industry was reconstructed and expanded. The production of precision electrical instruments for dosimetric measurements was begun. The modernization and improvement of other types of equipment were more frequently introduced, going beyond the framework determined by licenses and contributing to the increase of quality.

The work of research agencies, whose activities resulted in concrete achievements with the adaptation of licensed technology, especially with the utilization of the national raw material base, was begun during this period. The research division of the chemical forces appeared in 1954 and contributed to the technical progress made in the field of the design, evaluation and introduction of chemical military equipment.

The third developmental period in various fields of chemical military technology took place over a span of years conditioned by many factors. This stage has lasted until today. It has been marked by the separate undertaking and solution of many important and difficult technical problems, which faced the chemical forces during the 1960's

and still confronts them today. There are no technical fields today in which our chemical forces cannot utilize our own original designs, which have received the recognition of our allies as weapons of the camp of socialist states and which correspond to contemporary world standards.

The above mentioned characteristics of the third developmental period were, of course, subordinated to the individual fields of chemical military technology. An exception to this is equipment designated for the detection and evaluation of radioactive contamination, whose development and improvement was closely connected to the development of nuclear weapons and the principles of their use.

7.2 CHEMICAL DETECTION EQUIPMENT

The chemical forces entered World War II prepared for attacks of battlefield gases from the era of World War I. The military division of battlefield poisons (BST) of that time, influenced by the nomenclature of German colored crosses (white, green, blue, yellow and red) led to the fact that the field of activity of the chemical forces, its organization, training processes and technical equipment were adjusted to the defense of the army and personnel against the effects of these groups of BST.

Experts of the chemical forces anticipated the use of phosgene and diphosgene, prussic acid, bromic acid, chloroacetophenone, lewisite and sulphuric yperite. The existence at this time of BST detection equipment, the discovery of Hitlerite chemical munitions, training devices and disinfectants confirmed the veracity of these predictions.

The chemical forces of the Polish People's Army, created inside of the USSR, possessed corresponding detection equipment. The detection of BST in the atmosphere, on the ground and on battlefield equipment was guaranteed by our chemical forces, equipped with indication systems--the SChR chemical-detector case.

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This system, based on the technique of rapid colorimetric reactions occurring in indication tubes, on powder and paper indicators, permitted the detection and discernment with sufficient sensitivity of arsine, prussic acid, chlorocyanigen, phosgene, sulphuric or nitric yperite and lewisite. It also allowed the taking of contaminated samples for analysis in tactical level chemical field laboratories.

Although chemical weapons were not used in World War II, their continued presence in the arsenals of the western states (including the terrible German phosphororganic compounds) during the years of the "cold war" has created a permanent threat.

The broadening of the "assortment" of battlefield poisons has led to the need for the production and introduction into the army of new detection systems, which are more sensitive, faster and surer than present systems. More modern chemical detection instruments replaced the SChR. These instruments allowed the detection of BST in the air, on equipment, on the ground and in camouflaging smoke. They also allowed the possibility of taking samples, of marking contaminated terrain and detecting contaminants under conditions of impaired visibility.

On the tactical level, the PChL-46 chemical field laboratory,

equipped with reagent systems, and laboratory and auxiliary devices, ensured the detection of chemicals. These laboratories, produced in the form of portable cases, also required trained operators and guaranteed the detection of BST and the analysis of air, soil, human, foodstuff and water samples.

The AL-2 mobile laboratory, built on the GAZ motor vehicle and supplied with the equipment and reagents necessary for the analysis of all chemicals, ensured the activity of all levels. Such technical developments of laboratories provided the chemical forces with many possibilities in the area of maneuverability and allowed them to secure on an operational level the complete detection of chemicals.

The further development of chemical weapons, represented in the production of new highly toxic BST and the improvement of their delivery and spreading systems (cassette bombs, missile warheads, aerosols, etc.) by the leading capitalist states, has established the conception of the wide use of these weapons in the eventuality of a conflict. These same reasons have led to new qualitative and quantitative tasks for chemical detection.

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The domestic production of a new generation of chemical detection instruments has begun, based on Soviet licenses.

For example, the PChL-46 chemical field laboratory has been replaced by the new version PChL-54, which can carry out the analysis of air, water, soil and human samples, utilizing new techniques--colorimetric, titrimetric, precipitation and stactometric analysis.

The new type of laboratory allows work to be carried out in the following fields:

- the detection of BST in the air, water, on life forms, on the ground and on battlefield equipment;
- the quantitative analysis of phosphororganic compounds, yperite, arsine compounds, alkaloids, heavy metals and others;
- the elementary analysis of unknown substances and the determination of the BST group to which they belong.

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Detection units were supplied with semi-automatic instruments in order to modernize the methods of testing contaminated air samples in indication tubes and in order to decrease chemical detection efforts. Semi-automatic instruments equipped with pumps powered by electric motors ensured the uniformity of air intake and improved the quality of BST indication.

The most versatile BST detection method has been shown to be the constant control of air intake, performed by automatic analysis-signalling instruments.

Consequently, the equipping of the chemical forces with automatic contamination signalling devices was begun in 1961-62. The detection of micrograms of phosphororganic compounds takes place on indication tape in these instruments. The instrument signals atmospheric contamination by lights and buzzers. In order to broaden the framework of the above mentioned signalling devices both in the army and in civil defense, chemical reagent systems have been designed and introduced to production.

The need for the assurance of adequate protection from fast acting

tactical and operational compounds has led to the chemical forces receiving new equipment in between 1959 and 1962--cars for contamination detection, and in later years--transports.

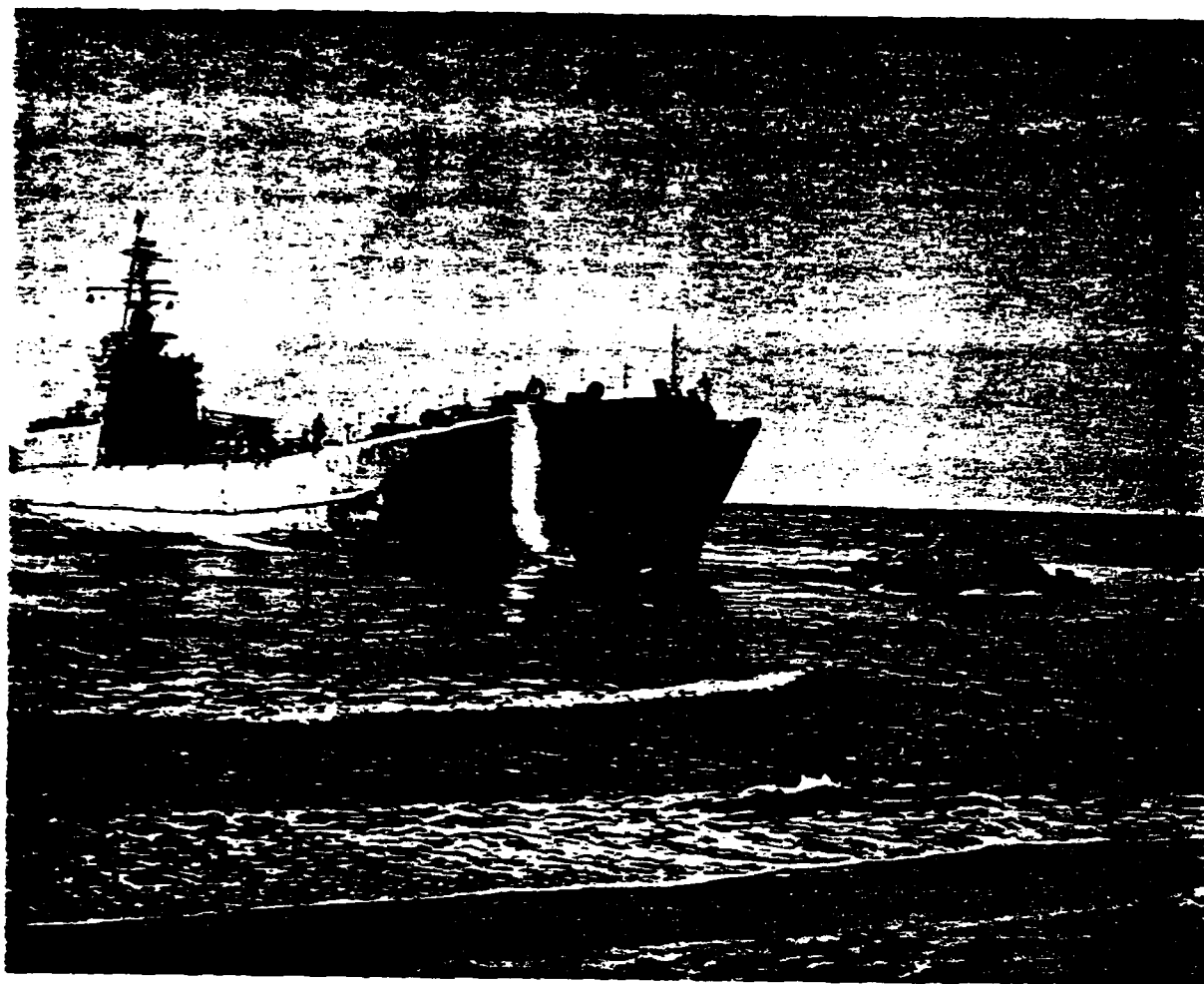
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Apparatuses and instruments, which ensure the detection of chemical, radioactive and meteorological contamination, the marking of contaminated areas and the maintenance of communications, are mounted in a functional manner on these vehicles.

The qualities of these transports include, besides their improved ability to traverse open land barriers, the more secure protection of the crew from gun fire and penetrative radiation.

The introduction into the chemical weapons arsenal of the Western states between 1965 and 1968 of new phosphororganic BST V type gases, the appearance of psychochemical compounds, new lacrimators (dinitryl o-chlorobenzylidene malonic "CS") and defoliants have caused new modifications to be made in chemical detection equipment and in analytical techniques. More sensitive analytical methods have been introduced for the detection and analysis of phosphororganic ST.

Signalling devices for biochemical contaminants are equipped with reagent systems designed and produced in Poland.

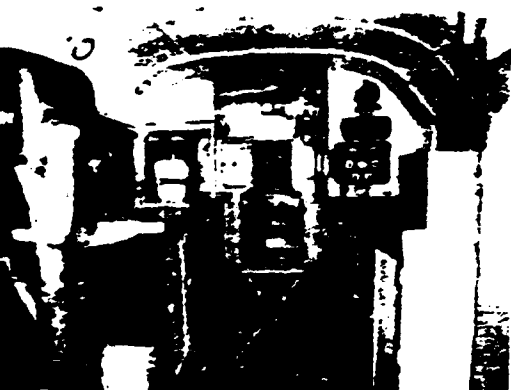
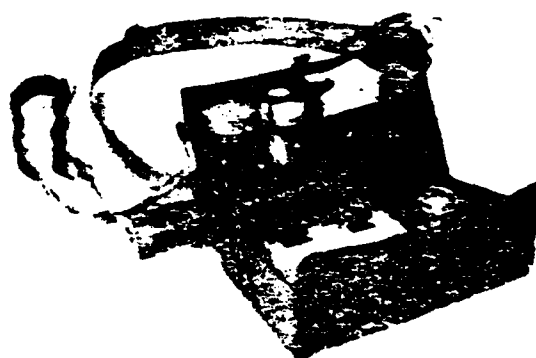


Coastal defense units' exercises



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The PChR-54
chemical
detection
instrument

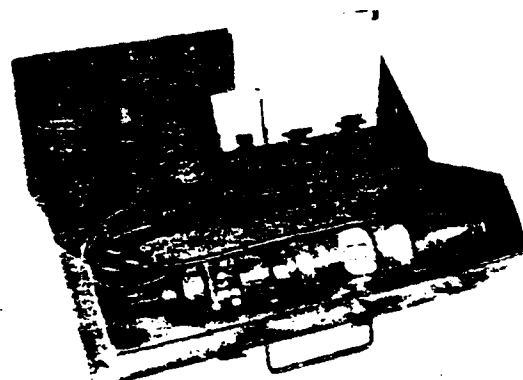


AL-3 chemical laboratory



(inside)

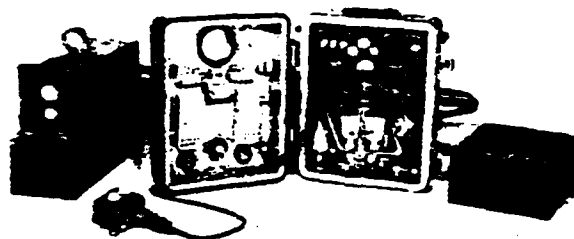
The PPChR semi-automatic
chemical detection instrument





The An-12 transport aircraft--the "Oder-Neisse 69" exercises

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The GSP-11 gas signaller

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The Gaz-69rs M-1 motor vehicle for
contamination detection

7.3 EQUIPMENT FOR THE PROTECTION OF THE RESPIRATORY SYSTEM

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One of the most important organizational-technical undertakings in the field of protecting forces from the the effects of battlefield poisons (BST), radioactive (SP) and biological (SB) aerosols is the supplying of soldiers with equipment adequate for the protection of the respiratory system, used either individually or collectively. This was recognized as a priority already in World War I, when chemical substances were used for the first time on a wide scale on the battlefield. It is also a real threat today.

At the beginning of the period of the formation of the Polish People's Army, the basic type of equipment serving for the protection of the individual soldier's respiratory system was a filtration gas mask composed of the SzM-2 face piece, with full head covering and the MT-4 aspirator, containing the anti-gas filter, a layer of alkaline granules for the absorption of acid vapors and gases and a layer of activated charcoal. The face piece was connected to the aspirator by a corrugated rubber foundation. The entire unit was carried in a cloth bag.

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Filter ventilation equipment was used to purify contaminated air in field and permanent shelters. An absorption filter analogous to the one used in the gas mask was the air purification element in these devices.

Domestic production of equipment for the protection of the respiratory system based on licenses supplied by the Soviet Union was

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begun at the start of the 1950's. The first domestically produced gas masks were an improved version in relation to those used during and immediately after the war. The essential improvements consisted of raising the quality of the materials used, while preserving practically unchanged the general design. Chemical granules were replaced by two layers of absorption-catalysts in the aspirator. One layer was intended mainly for the absorption of acid vapors and gases; the other had catalytic oxygenation properties and was intended for the absorption of, for ex., arsine. The anti-gas filter remained unchanged, as did the aspirator's dimensions. The face piece of the new mask did not differ concerning the design from the earlier one. The rubber composition of the head band was made more elastic.

In the later half of the 1950's based on Soviet licenses, Polish industry began the production of improved types of masks. Not only was the production of the new type of masked mastered, but during this stage a series of valuable modifications were also introduced. The most important achievements in this field must be credited to the working out of absorbants on the basis of domestic materials (mineral coal), to the mastering of the production of new types of filter paper and effective anti-corrosion protection for the mask's metallic elements, and to the modernization of face parts by the designing of phonic chambers.

The further progress in the field of equipment for the individual protection of the respiratory system was directed toward improving exploitation properties (decreasing the overall dimensions, lengthening the time the mask can be worn, etc.). The joint efforts of research and technological institutes led to the designing and serial production of modern, general military, small dimensioned masks. A new type of mask for the civilian population was also produced.

During the war and the first years after it, most attention was turned towards individual systems for the protection of the respiratory system. The equipment of this period, which served to purify air of BST vapor or aerosols and radioactive dust, was not part of the soldier's standard equipment. The basic condition for the installation of air purification equipment for shelters was its air-tightness. In the 1940's the army did not possess air-tight permanent or mobile shelters and no permanent shelters were constructed in the country. After 1950 the need arose to supply the army and the nation with shelters equipped with air-purifying devices, known as filter-ventilation equipment or UFW. The scientific-research base and industrial potential of Poland allowed this equipment to be produced in Poland.

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In the 1960's work on new designs for individual elements and the complete UFW system was begun in both military and civilian research agencies. The valuable research of military and civilian specialists in the field of air decontamination deserves special attention. This work allowed the development of initial air purification elements in the form of reticular and fibrinous prefilters. These dust trapping prefilters could be regenerated easily by rinsing with water or blowing clean with air. They found application in permanent objects, field shelters and air-tight mobile objects, as well as in the national economy.

The evolution of the strategy of war and the quantitative growth of various types of mechanized vehicles in the military, which had to be prepared for operation under conditions of contamination, created the need to secure clean air for the crews inside these vehicles. This need led to domestic experimentation and the ultimate production of

new UFSW filter-ventilation equipment, intended for air-tight military motor vehicles.

7.4 SKIN PROTECTION EQUIPMENT

When weapons of mass destruction are used, not only is equipment for the protection of the respiratory system necessary, but so is that which protects the external parts of the human body. This task is met by so-called skin protection equipment. This includes articles which supplement or replace ordinary clothing and footwear. These articles are produced from special materials which more or less resemble ordinary or special clothing (a two piece protective suit, overalls, apron, shoes, normal clothing impregnated with materials, etc.).

At the beginning of World War II the Polish Army possessed a limited number of one- (overalls) and two-piece cotton or linen protective suits, impregnated with material for protection against the drops and vapor of burning gases (yperite and lewisite). At the war's very beginning research began on impregnators resistant to the effects of moisture while simultaneously showing corresponding protective properties.

A sufficient number of skin protection devices with suitable exploitation and protective values was found only in the ranks of the Polish People's Army, which was fighting at the side of the Soviet Army. It must be stressed that already by this time the division, which exists up until today, of skin protection equipment into special and general military categories was made. The first category was and is for subdivisions of the chemical forces, which scout and

decontaminate polluted areas, as well as for some other forces (armor, naval and other forces). The second category is for every soldier.

In connection with this, the first category of equipment was produced in its entirety from relatively rough and heavy insulation material. A person could remain in the protective suit only for a limited period (from 15 minutes to 8 hours depending upon the temperature). The second category of protective equipment could, from the nature of things, be lighter and better ventilated, allowing the soldier freedom of movement during battle.

Immediately after the war the chemical forces were equipped with skin protection equipment obtained or purchased from the Soviet Union. The Polish production of such equipment, based on Soviet licenses, was tied to the level of development of the domestic raw material and industrial base. Therefore, a complete assortment of treated clothing began to be produced, followed by the production of rubberized and overall resistant clothing. The production of paper capes and impregnated underwear and uniforms was also begun.

The appearance of phosphororganic poisons (tabun, sarin, DFP, soman, and later, the so-called V-gases) with a toxicity several times greater than yperite or lewisite in the arsenals of the western states created the need to improve the existing skin protection equipment; this included increasing its air-tightness and resistance to the effects of chemical poisons while simultaneously decreasing its weight.

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Rapidly developing industrial offshoots created a sufficient basis for this type of undertaking. This allowed the army to be equipped

with a light one-piece suit connected with shoes and three-fingered rubber gloves, instead of various special skin protection articles. 215

General military protective clothing also underwent modification. A standardized protective poncho and three-fingered gloves (and later rubber-five-fingered) was introduced, produced from a domestically designed rubberized fabric.

A little later in 1950 the Western camp began more frequently to talk about the possibility of using nuclear or biological weapons, as well as mass incendiary bombing, in a future war. In connection with this, intense research on the serviceability of the skin protection equipment possessed in view of new attack systems was begun. As a result of this research it was learned that the existing protective clothing was adequate for protection against radioactive dust and penetrative bacteria. It was also discovered that the weakest side of existing protective materials was its relatively easy combustibility: it could not, therefore, guarantee sufficient protection against the effects of heat radiation coming from a nuclear blast or the dropping of napalm.

Between 1955 and 1965 the theoretical and experimental viewpoint that protective clothing must meet all demands of modern warfare, that is, it must protect the soldier from all the effects of weapons of mass destruction while restricting his maneuverability as little as possible, was crystallized. In connection with this, it was established that the existing division of skin protection equipment into special and general military clothing would remain in effect, with the exception that the first category must be significantly lighter and less penetrable than existing clothing, and that the second category must better protect the soldier especially from the 219

vapor of new types of BST and from the effects of the flash radiation of nuclear blasts. Therefore, the paper protective cape was no longer acceptable as an element of general military protective clothing.

Research in the field of skin protection equipment took four parallel directions:

- the development of thin and light cotton and synthetic fabrics;
- the application of new chemically resistant synthetic rubbers in the production of thin and less penetrable protective coverings;
- the development of new additives for rubber compositions, which decrease their combustibility (antipyrenes);
- the development of new impregnators for underwear and uniforms, which secure their protection against the vapors of new types of BST.

The result of such tasks assigned to the research institutes and industry was the development of new material for protective clothing in 1958. From this fabric were produced a special protective oversuit and completely non-penetrable elements, in which the paper cape was replaced by a general military protective overcoat.

A significant improvement in the technical parameters and materials used in protective clothing was obtained in the next period by the use of synthetic fabrics and the development of non-combustible rubberized coverings. New impregnators for underwear and uniforms, which bonded the vapor and droplets of BST and prevented their desorption from the fabric, were also developed in this last period.

Therefore, skin protection clothing, with which our army is now equipped, completely protects our soldiers against all the effects of weapons of mass destruction.

The developmental work in the field of skin protection equipment in recent times has been aimed at designing light, chemical and moisture resistant, and non-combustible materials for the production of non-penetrable elements (capes, ponchos, gloves) of general military protective clothing. Those elements, which protect against chemical contamination, can be used only once.

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The L-2 protective oversuit

Table 7.1 General Military skin protection equipment during the war (for key, see next page).

| 1 Nazwa 1 | 2 Ukompletowanie 2 | 3 Rodzaj materiału 3 | 4 Właściwości ochronne 4 | 5 Właściwości eksploatacyjno-użytkowe 5 |
|--------------------------------------|---|---|---|--|
| 6 Ogólnowojskowy komplet ochronny | 7 Ogólnowojskowa odzież filtracyjna | 8 Normalne umundurowanie wojskowe wraz z bielizną, impregnowane substancjami absorbującymi pary i drobne kropki BST. | 9 Ochrona przed parami i drobnymi kroplami BST typu parzącego (2—3 godz.). | Zalety: 10 zachowanie dość dużego stopnia przepuszczalności powietrza (80%), długoletni okres składowania. Wady: 11 niezbyt przyjemny zapach, łatwe brudzenie się tkaniny, łatwa palność, możliwość desorpacji BST zaabsorbowanych na tkaninie. |
| | 12 Rękawiczki ochronne | a) Tkanina bawełniana pokostowana 13 | Ograniczony (30—60 min.) czas ochrony przed BST typu parzącego, w postaci kropli i par. | Zalety: 15 mała masa (0,5 kg). Wady: 16 krótkotrwały okres składowania, znikoma odporność na odkażanie, działanie wody i mieszanek zapalających. |
| | | b) Tkanina bawełniana gumowana kauczukiem butadienowo-styrenowym. 17 | 8 Długotrwała ochrona przed przenikaniem BST typu parzącego w postaci kropli i par. | Zalety: 19 długotrwały okres składowania (3—5 lat), odporność na działanie wody i wielokrotne odkażanie. Wady: 20 duża masa (1—1,2 kg), palność. |
| | 21 Rękawice ochronne pięciopalcowe lub trójpalcowe | 22 Guma lub tkanina bawełniana gumowana kauczukiem butadienowo-styrenowym. | Jak w rubryce 4, pkt. b). 23 | Jak w rubryce 5, pkt. b), (ciężar 0,3—0,4 kg). 24 |
| | Narzutka ochronna 25 | Specjalny papier nasączony klejami białkowymi, w późniejszym okresie dodatkowo wzmocniony siatką tkaninową. 26 | Ograniczony czas ochrony (10—15 min.) przed ciekłymi BST typu parzącego. 27 | Zalety: 28 mała masa (ok. 0,4 kg), możliwość szybkiego zdejmowania, długoletni okres składowania (3—5 lat). Wady: znikoma odporność na działanie wody, mała wytrzymałość mechaniczna, łatwopalność. 29 |

Table 7.1 General military skin protection equipment during the war

1. name, 2. complete unit, 3. type of material, 4. protective properties, 5. usage properties, 6. general military protection unit, 7. general military filtration clothing, 8. normal military uniform together with underwear, impregnated with substances which absorb the vapor and droplets of BST, 9. protection against the vapor and droplets of burning BST (2-3 hours), 10. advantages: maintenance of a sufficiently high level of air penetrability (80%), long-term storage period, 11. shortcomings: a lack of pleasant odors, easy soiling of fabric, easy combustibility, the possibility of the desorption of BST absorbed in the fabric, 12. protective poncho, 13. a) coated cotton fabric, 14. limited protection period (30-60 min) against burning BST in the form of vapor and droplets, 15. advantages: light weight (.5 kg), 16. shortcomings: short-term storage period, minimal resistance to disinfectants, the effects of water and combustible mixtures, 17. b) cotton fabric rubberized with styrene-butadiene rubber, 18. long-term protection against penetrative burning BST in the form of droplets and vapor, 19. advantages: long-term storage (3-5 years), resistance to the effects of water and multiple disinfecting, 20. shortcomings: heavy weight (1-1.2 kg), combustibility, 21. five- or three-fingered protective gloves, 22. rubber or cotton fabric rubberized with styrene-butadiene rubber, 23. like #14, 24. like #15 (weight .3-.4 kg), 25. protective cape, 26. special paper saturated with albuminous gum, and later supplemented by reinforced reticular fabric, 27. limited protection period (10-15 min) against burning BST liquid, 28. advantages: light weight (.4 kg), rapid removal, long-term storage (3-5 years), 29. shortcomings: minimal resistance to the effects of water, low mechanical reliability, ease of combustibility

Table 7.2 Special skin protection equipment during the war (for key, see next page).

| Lp. | 2 Nazwa i przeznaczenie | 3 Ukompletowanie | 4 Rodzaj materiału | 5 Właściwości ochronne | 6 Właściwości eksploatacyjne-użytkowe |
|---------|--|---|--|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 7 | Odzież ochronna ciężka. (Dla pododdziałów odczyszczenia sprzętu ciężkiego i terenu oraz zadymienia) | Kombinezon Fartuch 8 | a) Początkowo z tkaniny bawełnianej pokostowanej 9 | Ograniczony (30-60 min) czas ochrony przed BST typu parzącego w postaci par i kropeł 10 | Zalety: 11 mała masa (kombinezon 3,2 kg, fartuch 0,4 kg) Wady: 12 krótki okres składowania, znikoma odporność na odczyszczenie, działanie wody i mieszanek zapalających. |
| | | | b) Tkanina bawełniana, gumowana kauczukiem butadienowo-styrenowym 14 | Długotrwała (kilka godzin) ochrona przed przenikaniem BST typu parzącego w postaci kropeł i par 15 | Zalety: 16 długotrwały okres składowania (3-5 lat), odporność na działanie wody i wielokrotne odczyszczenie. Wady: 17 duża masa (kombinezon 3,8 kg, fartuch 0,6 kg), palność |
| | | Rękawice pieciopalcowe. Buty z cholewami 13 | Guma (kauczuk naturalny lub butadienowo-styrenowy) 25 | Jak w rubryce 5, pkt. b) 26 | Jak w rubryce 6, pkt. b) (ciężar rękawic 0,3 kg, butów 2,0 kg) 22 |
| 2 18 | Odzież ochronna lekka. (Dla pododdziałów odczyszczenia sprzętu lekkiego i rozpoznania skażeń chemicznych). | Komplet składający się z: bluzy z kapturkiem, spodni połączonych z butami i rękawicami trójpalcowymi 19 | Tkanina bawełniana powlekana polizobutylenem 20 | Wystarczająca (do 2 godz.) ochrona przed przenikaniem BST typu parzącego w postaci kropeł i par. 21 | Zalety: 23 mała masa (2,5-3,5 kg), odporność na działanie wody i wielokrotne odczyszczenie, długotrwały okres składowania (3-5 lat). Wady: 24 palność |
| 3 | Odzież ognioodporna. (Dla miotaczowych ognia i załóg czołgowych). 27 | Kombinezon z rękawicami ochronnymi. Maski ochronna. 28 | Flanela powlekana kauczukiem chloroprenowym z dodatkiem antypirenow (soda, sole boru itp.). 29 | Ograniczony czas ochrony (40-60 min.) przed BST typu parzącego w postaci kropeł i par. 30 Ochrona przed działaniem mieszanek zapalających. | Zalety: 31 niepalność, odporność na działanie płynnych paliw i smarów. Wady: 32 duża masa (5 kg). |

Table 7.2 Special skin protection equipment during the war

1. number, 2. name and designation, 3. complete unit, 4. type of material, 5. protective properties, 6. usage properties, 7. heavy protective clothing (for subdivisions which disinfect heavy equipment, open terrain and smoke), 8. overalls, apron, 9. a) initially from coated cotton fabric, 10. limited (30-60 min) protection period against burning BST in the form of droplets and vapor, 11. advantages: light weight (overalls 3.2 kg, apron .4 kg), 12. shortcomings: short-term storage period, minimal resistance to disinfectants, the effects of water and combustible mixtures, 13. five-fingered gloves, boots, 14. b) cotton fabric, rubberized with styrene-butadiene rubber, 15. long-term protection (several hours) against penetrative burning BST in the form of vapor and droplets, 16. advantages: long-term storage (3-5 years), resistance to the effects of water and multiple disinfecting, 17. shortcomings: heavy weight (overalls 3.8 kg, apron .6 kg), combustibility, 18. light protective clothing (for subdivisions which disinfect light equipment and detect chemical contamination), 19. a complete unit composed of: tunic with hood, trousers connected to boots and three-fingered gloves, 20. cotton fabric, coated with polyisobutylene, 21. sufficient protection (up to 2 hours) against penetrative burning BST in the form of vapor and droplets, 22. like #17 (weight of gloves .3 kg, boots 2 kg), 23. advantages: light weight (2.5-3.5 kg), resistance to the effects of water and multiple disinfecting, long-term storage (3-5 years), 24. shortcomings: combustibility, 25. rubber (natural or styrene-butadiene), 26. like #15, 27. fire resistant clothing (for flame thrower operators and tank crews), 28. overalls with protective gloves, protective mask, 29. flannel coated with chloroprene with the addition of antipyrenes (soda, boric salts, etc.), 30. limited protection period (40-60 min) against burning BST in the form of droplets and vapor, protection against the effects of combustible mixtures, 31. advantages: non-combustibility, resistance to the effects of liquid fuels and lubricants, 32. heavy weight (5 kg)

The enormous power of a nuclear explosion and the diversity of its destructive factors have created the need to develop the methods, means and principles for actions, which would allow forces not only to survive an eventual nuclear war, but which would simultaneously allow the retention and fulfilling of the defined functions and tasks of the state, army, economy, civil defense, etc. Thanks to studies of the results of the nuclear blasts at Hiroshima and Nagasaki, as well as to the information obtained from nuclear tests, both the picture of the real threat and the possibilities of protection from this threat (and methods which would limit losses) have begun to be crystallized.

In order to solve this problem, a new field of knowledge--dosimetry, which is concerned with the study of the properties of radiation and the effects of radiation on living organisms--has appeared in individual armies, based on the experiments of institutes occupied with the research and development of applied nuclear technology.

Dosimetry has arisen on the point of contact of such sciences as nuclear physics, chemistry, electronics and biology, and is closely tied to measurement technology. One of the most important branches of dosimetry is made up of the methods and means for the detection of ionic radiation in order:

- to define the character and scale of radioactive contamination and its effect on the military efficiency of military personnel;
- to detect the safest regions for placement of personnel, and to decontaminate or by-pass contaminated zones;
- the establishment, in the given situation of contamination, of the most rational military operation and the complete usage of protective

equipment.

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The task of meeting these goals was charged to the contamination detection and evaluation service, created within the framework of the chemical forces of individual armies. There also appeared the need to equip this service with the corresponding technical means, which would facilitate the fulfillment of this task. The history of the development of the technical equipment of the radioactivity contamination detection and evaluation service can be divided into stages, closely connected to the development of nuclear weapons and the principles of their usage, to the development of measurement technology and to the development of military command technology.

The first stage corresponded to the periods, in which--with a limited number of nuclear devices--the basis of their use was anticipated to be, above all, the destructive effect of the blast's concussion waves and flash radiation. An air explosion was decided upon in the operational plans in order to maximize the military effect. Therefore, the task of the detection service was limited to detecting small contamination zones. The equipment for the detection and control of the contamination and radiation dose was limited to simple, portable devices, operated by infantry or motorized patrols, dosimeters for the group control of doses, simple radiometers etc.

The second stage was connected to the increase of nuclear weapons in the enemy's arsenal. In this period the concept of the usage of nuclear bombs was modified. The creation of gigantic contamination zones (nuclear barriers) was anticipated, both in the area of military operations and deep behind enemy lines. Therefore, new tasks were presented to the contamination detection and evaluation service. Systems for the detection and evaluation of contamination were

created, which encompassed measurement elements, communications systems and correspondingly equipped divisions in the tactical and operational command levels, interested in the gathering and processing of information on contamination. The total state of military personnel was conditioned by the control of individual radiation dosages.

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The first dosimetric equipment was provided to Poland by the USSR in 1955. It then consisted of radioactive contamination detection systems and dosimetric control.

The first dosimetric device completely worked out in Poland (1958) was the D-08 roentgenometer. It was an instrument with technical parameters and usage values, which approximated those of the Soviet-made DP-1-A roentgenometer.

At the beginnings of the 1960's we possessed a domestic technical base, sufficient to meet the majority of military needs with domestically produced equipment. A system of specialists, moreover, arose in Poland, which could undertake original work, both in the field of new designs and contamination detection and evaluation methods.

The 1960's are marked by the following tendencies:

- a) the growth in the need for surface roentgenometers;
- b) the removal of equipment with limited range and detection possibilities and the reduction in the number of models;
- c) the establishment of new criteria and principles for the equipping of subdivisions with dosimetric instruments;
- d) the possibility of the utilization in domestic technology of

semiconductors in dosimetric instruments and consequently, the decrease of these instruments' weight and dimensions, while simultaneously increasing their reliability;

e) the placing of new tasks to equipment for the control of individual radiation dosages resulting from the equipping of the enemy's forces with low yield nuclear weapons with ionic radiation (gamma and neutron radiation), which exceed the destructive radiation of shock waves and flash radiation, as well as from the results of research in the field of radiobiology.

The development of the technology caused by these tendencies can be categorized in the following manner: between 1963 and 1965, based on dosimeters with their own readouts, small dosimetric systems and simple transistorized devices for the charging of these dosimeters were designed and produced. Such elements allowed the easier and more elastic utilization of dosimeters in the subdivisions. The DP-66 roentgenic radiometer, a universal, transistorized device, adapted both for the measurement of the power of a dose of radiation in the open field and for the measurement of the level of the radioactive contamination of various objects and materials, was also designed and serially produced. It replaced two devices then used in the Polish Army, namely the roentgenometer and radiometer. This instrument obtained high marks during the comparison of similar types of devices, carried out by specialists of the Warsaw Pact armies.

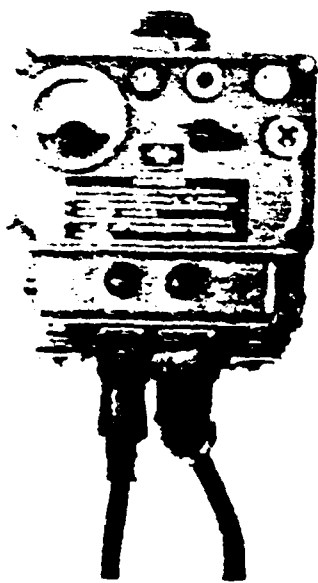
The body-mounted roentgenometer is another important and totally Polish-designed instrument. It allows the detection of radioactive contamination with the use of motorized vehicles (automobiles, armored transports, tanks) and helicopters. Moreover, in order to secure the device's necessary universality, it was adapted for mounting on ship decks and the surfaces of stationary objects (shelters, factory buildings, guardhouses, fire watchtowers, etc.).

The body-mounted roentgenometer allows the power of radiation dosages to be measured and can obtain optical and acoustical signals the moment when radiation dosage exceeds allowable values.

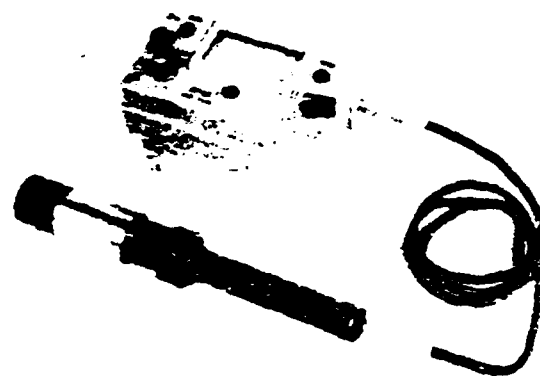
At the end of the 1960's a system for the control of radioactive and chemical contamination in areas where many stationary objects are located was designed. 224

A separate group of instruments is made up by elements of a contamination detection and evaluation system, which serves to mechanize the labor connected to the processing of data about contamination, in order to establish the proper operation of forces in a defined situation of contamination and to determine their proper protection against contamination.

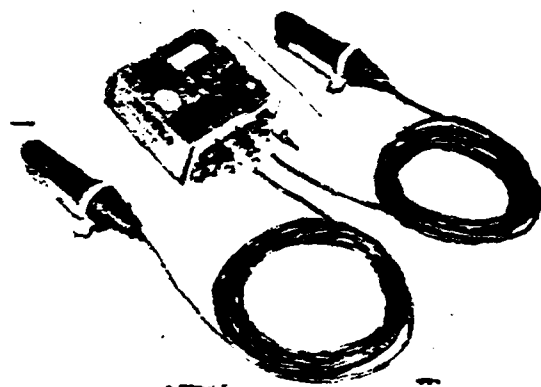
The work of recent years, as well as that going on now and planned for the future, is aimed at the adaptation of the system of contamination detection and evaluation to the needs of automated military command systems.



The DP-3 body mounted roentgenometer



The DP-66 roentgenic--radiometer



The DPS-68 body-mounted roentgenometer



Devices for evaluating the situation of radioactive contamination

7.6 EQUIPMENT AND MEANS FOR DECONTAMINATION

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The army's defense against the results of a chemical, biological and atomic attack encompasses the protection of the body and respiratory system, detection of the contamination's character and magnitude, and, finally, the contamination's removal. So-called special measures, which have do to with decontamination or disinfection, also serve to meet these goals. Decontamination consists of chemical neutralization by aid of disinfectants, flushing with water or solvents with regard to the insulation of the contaminated surface in order to make direct contact with it impossible. Decontamination can be partial or total. Partial decontamination deals mainly with those parts of weapons and equipment which come into contact with their operators during battle. Partial decontamination is performed immediately during battle without the use of anti-chemical protection.

Total decontamination encompasses the total surface of the equipment and weapons. It is performed after the battle has ended or at stations for the issuance of special measures.

The Polish People's Army during World War II was equipped with the types of disinfectants for battlefield poisons mentioned below.

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1. The IPP-5 or IPP-6 individual, sanitary anti-chemical protection kit, intended for the self-decontamination of skin or first-aid for others contaminated individuals. These kits also served for the partial decontamination of weapons and military-technical equipment. They consisted of a container with a solution of dichloramine in dichloroethane or alcohol, or with dry calcium hydrochlorite, and

gauze tampons for wiping the disinfectant on the surface.

2. Devices for the total disinfection of equipment and weapons.

a) Multistationed disinfecting devices for the spraying of liquid disinfectants (chloroamine solutions in organic solvents, sulphuric chlorides, organic solvents, etc.). The DK-1 portable weapons disinfecting kit belongs to this group and is composed of a tank containing the disinfectant and a hand pump with collector, rubber tubes and spray nozzles.

b) Backpack devices for the disinfection of light weapons, battlefield equipment, automobiles and small structures.

3. Open-terrain disinfecting equipment.

a) Installations and equipment for the spraying of dry disinfectants (chlorinated lime). The ACHI-5 or PDM installations mounted on cars must be included in these systems. They consist of tanks, which hold the disinfectant, the propulsion mechanism together with a moveable spray cylinder and a lever mechanism, which regulates the intensity of the disinfectant's spray.

b) Vehicular installations for disinfecting open-terrain spread liquid disinfectants (sulphuric chloride, water suspended chlorinated lime). These types of installations consist of disinfectant cisterns, vacuum pumps and outflow conduits for the disinfectant's even spreading.

4. Installations for the disinfecting of uniforms included the BU-2 and BU-3 portable boiler installations for the disinfecting of uniforms, underwear, shoes and rubber gloves by the boiling or vapor-ammonia method. The boiling method consists of subjecting the

uniform to the effects of a slightly boiling solution of sodium or ammonium carbonate with ichtyol. The vapor-ammonia method consists of placing elements of the uniform separately into special chambers filled with ammonia gas obtained from the dissolution of ammonia carbonate by aid of water vapor.

Some of the mentioned types of equipment were still used in the army for a long time after the war's end. During this period decontamination equipment was supplemented with deliveries from the Soviet Union. At the same time the domestic production and modernization of decontamination equipment was begun, utilizing the relatively developed research and industrial base of the country.

The fundamental turning point in the development of decontamination equipment and means followed at the end of the 1950's in connection with the further development of battlefield chemical poisons and nuclear weapons. Reservoirs of water solutions for the elimination of radioactive contamination (deactivation) were designed. Highly effective surface flushes were also developed. A further step forward in the field of decontamination equipment was the domestic designing of a new vehicular spreading installation with a water heater for the disinfection and deactivation of equipment, weapons and open-terrain and for bathing.

The development of nuclear and thermonuclear weapons created the threat of mass contamination over a huge area, and the rapid mechanization of the military led to an increase in the tempo of battle and the disposition of troops. Consequently, the need arose for the development of a broad range of individual means and equipment, as well as for an increase in the effectiveness of equipment for special measures, in order to meet all tasks rapidly without having

to interrupt battle action. The developmental stage of this complicated problem is already behind us. The result of this stage is a broad series of designs: individual disinfectant and decontamination packets, and individual disinfectant and decontamination devices for motor vehicles, weapons and military-technical equipment.

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7.7 SMOKE SCREEN DEVICES

Smoke screens are used mainly for masking and signalling, and, therefore, smoke screen devices are divided accordingly. Contemporary techniques in the field of masking smoke screens are basically a product of our period, when developments in the field of theoretical designing, practical experimentation, measurement methods, conditions and principles for the utilization of smoke screens paralleled the general progress of technology. The Polish Army, fighting at the side of the Red Army during World War II, was equipped with white and black smoke hand grenades, smoke candles, portable installations for smoke production and smoke artillery shells.

In the 1950's the domestic production of smoke candles was begun, initially based on licensed documentation, but later on domestic designs. This concerned, for example, the adaptation of technology to the domestic base of raw materials, the modernization of designs, ignition methods, etc. In later years medium and large smoke generators and colored smoke signalling candles (black, red, yellow and orange) were developed.

The basic purpose for the use of battlefield smoke screens is the

possibility of camouflage during observation in visible light. Smoke only weakly absorbs other types of electromagnetic radiation, such as infrared, radar and laser rays. Therefore, in connection with the great progress made in observation technology, utilizing nocturnal vision and radar device, infrared photography and even laser observation equipment, the significance of masking battlefield smoke screens is now limited. Also, the introduction into warfare of new tactical and operational elements, especially the greater tempo of operations, diffusion and surprise, has eliminated the use of smoke as a factor of camouflage. Nevertheless, smoke screens still find application in the local masking battlefield maneuvers of subdivisions.

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7.8 PYROGENIC WEAPONS

Fire as weapon of war belongs to the oldest type of armaments. Even today fire has not lost its effectiveness, especially in the form of different pyrogenic weapons both in tactical and operational activities, as well as deep behind the lines of the combatants.

Pyrogenic weapons have undergone essential changes since ancient times and today's arsenal of flammable materials and the equipment for their use is rich and varied. Pyrogenic weapons were used in World War II on a mass scale and their destructive power proved to be on par with other types of weapons.

The use of pyrogenic weapons is intended for the destruction of armed forces and the setting afire of various objects (warehouses, fuel depots, towns, settlements, forests), the disruption or weakening of the tempo of battle and the paralyzing of the functioning of, for ex., industry, transport and other important branches of the national

economy. Included in the category of pyrogenic weapons are:

- 1) flammable mixtures, which burn after ignition has been initiated (thermite, electron, pyrogel, napalm);
- 2) self-igniting substances, which burn upon contact with the air or water (white phosphorous, sodium, potassium, metallorganic compounds--chiefly the methyls and ethyls of clay).

The equipment, used to fire and transport flammable materials, includes:

- flame throwers;
- flammable aerial bombs;
- flaming mines.

During World War II and the immediate post-war years, the Polish Army was equipped with Soviet ROKS-3 backpack flame throwers and FOG-2 fugacitic flame throwers. Both type of flame throwers used uncondensed (gasoline, propulsion oil, etc.) and condensed liquid fuel--mainly with gelling thickener (naphthelates of clay).

23.

The ROKS-3 flame thrower consisted of a rifle connected to a tank of flammable mixture and to a cylinder with compressed air. It could deliver 1-3 shots up to a distance of 35 m.

The FOG-2 flame thrower consisted of a steel tank, equipped with a siphoning tube and a socket for the powder charge. Buried in the ground, the device would usually create a fugacitic field. Propelled by the gases created from the powder, a flaming stream of napalm was launched over a distance of around 70 m. The FOG-2 could deliver only one round.

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THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY 30
YEARS OF DEVELOPMENT(U) FOREIGN TECHNOLOGY DIV
WRIGHT-PATTERSON AFB OH H LATOS 20 DEC 83

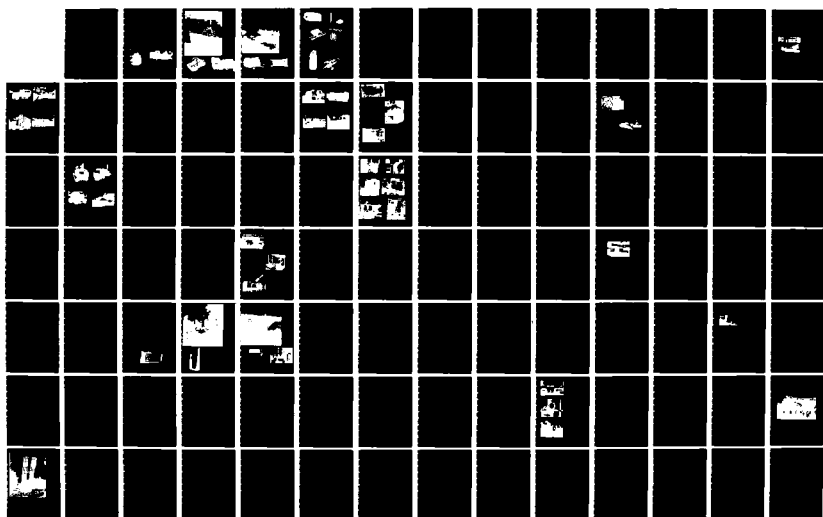
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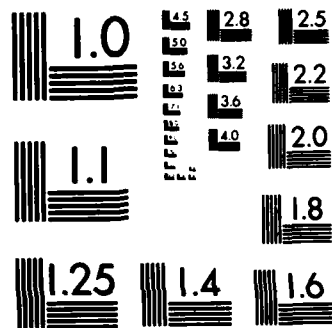
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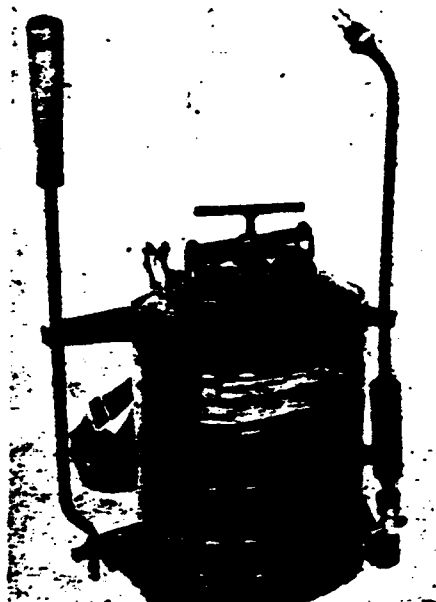
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The Pomeranian Second Flame Thrower Battalion, which was part of the First Polish Army, was equipped with both types of weapons. This battalion participated effectively in battles in Western Pomerania, as a special unit of the chemical forces.

In the 1950's chemical subdivisions were equipped with new types of backpack and portable flame throwers. They were adapted for the use of napalm mixtures condensed by naphthelates of clay and characterized by their great range, sure functioning, large quantity of flammable mixture and great accuracy.

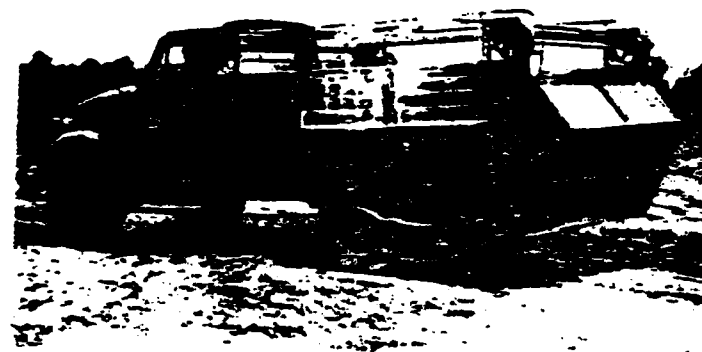
Pyrogenic weapons, playing the role of an effective type of support weapon, were improved in direct proportion to the improvement of the means of war and its technology. The basic goals in improving these types of weapons are increasing range, accuracy and the destructive capacity of the napalm mixtures.

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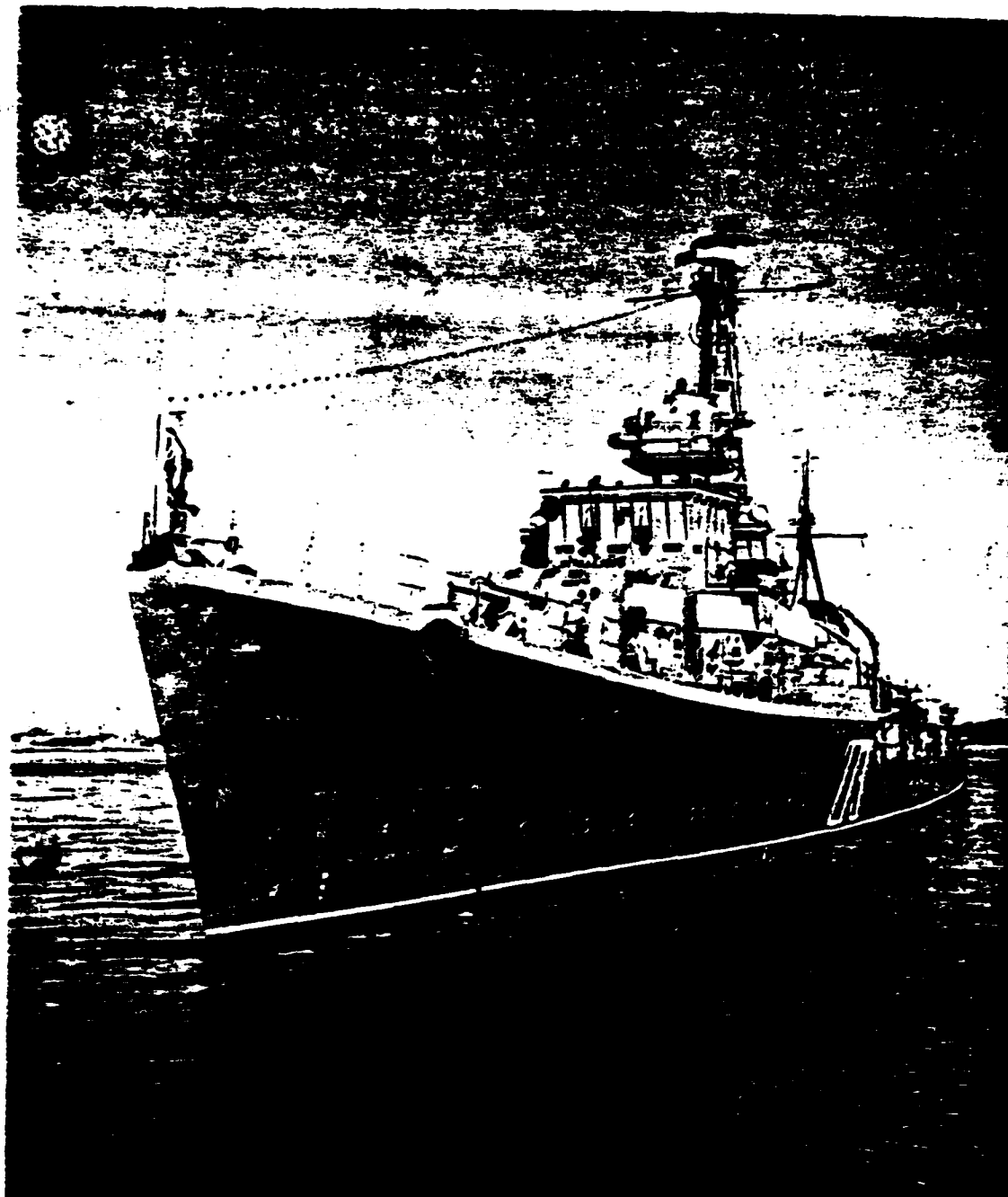


The RDP-4 disinfecting
backpack device

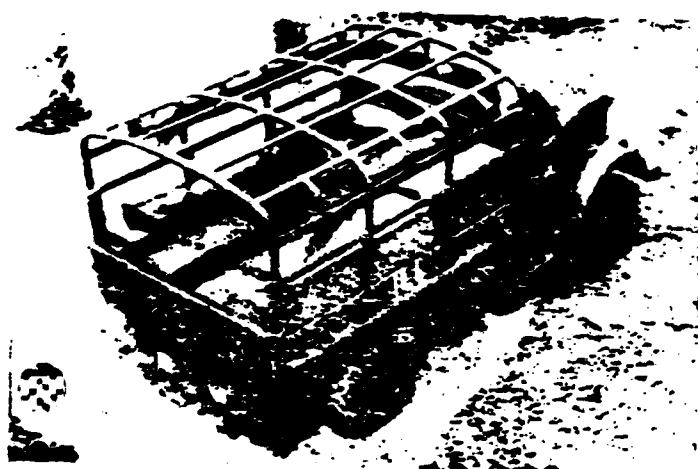
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The PDM open-terrain disinfecting
installation

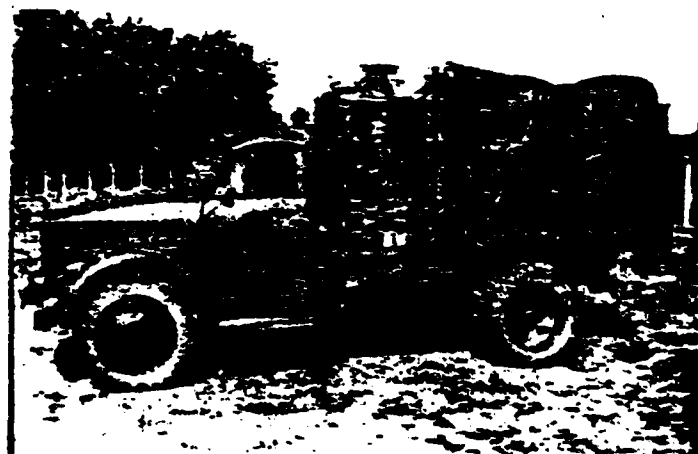


The destroyer,
ORP Grom



The ADM-48 weapons disinfecting
installation

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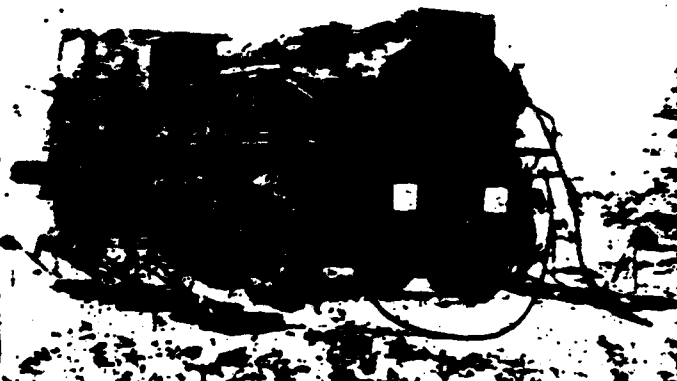


The DDA disinfectant-bath
installation



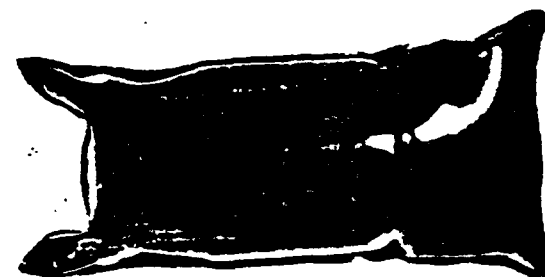
A torpedo boat
in action

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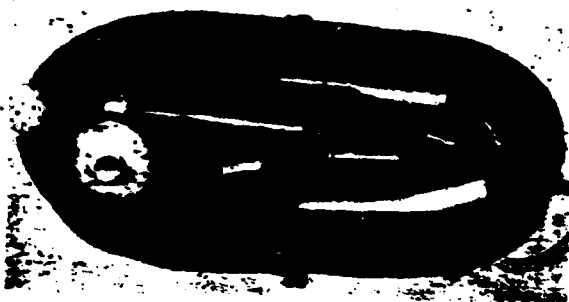


The IRS spraying installation

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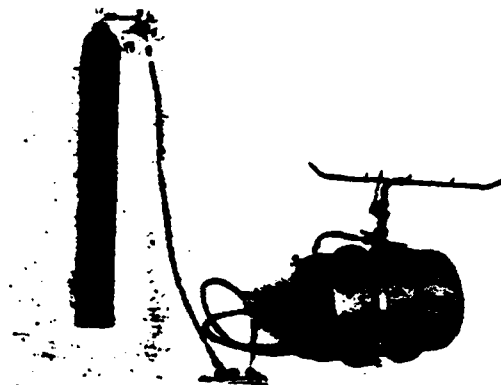


The PChW-013 individual
disinfecting packet



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The EZS vehicular ejection system

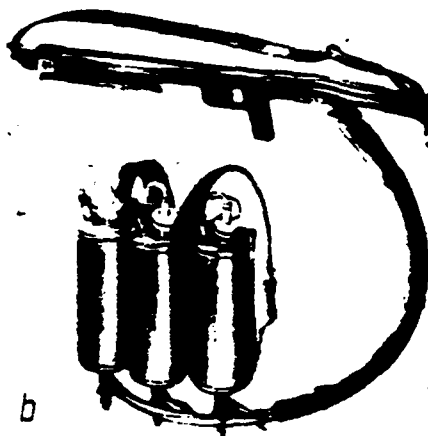


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A siphoned smoke tank



a



b

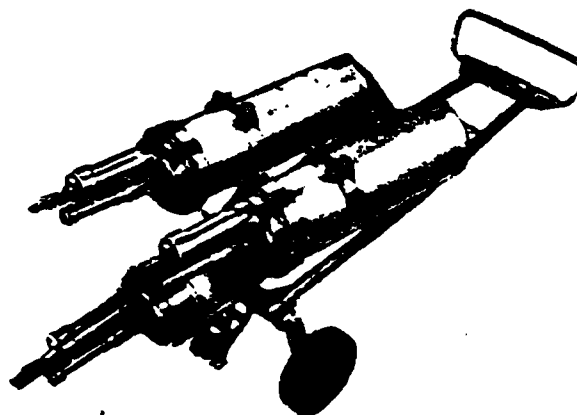
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a) The ROKS-3 backpack flame thrower

b) The LPO backpack flame thrower



a



b

a) The FOG-2 heavy flame thrower

b) The TPO heavy flame thrower

7.9 THE CHEMICAL FORCES AND THE NATIONAL ECONOMY

When speaking about the progress made in equipment for protection against weapons of mass destruction and the unquestionable achievements of Polish industry and science in this field, one must also point to the reverse effect of this equipment, by which the demands and inspirations of military specialists served to stimulate the growth of the technical level and the modernization of the technology of the national economy. Thanks to the initiatives of the chemical forces, for example, mold formation by means of high pressure injection was initiated in the rubber industry, the production of highly effective cardboard filters was begun in the timber industry, and a factory, which produced devices for the measurement of ionic radiation, was constructed for the Bureau of Atomic Energy.

Scientific-research activities, undertaken to meet the needs of the national defense, were also applied in the national economy. This also relates to a series of testing methods, as, for example, the method for testing activated charcoal and absorbants under dynamic conditions, the method for testing the resistance of various materials to the effects of the flash radiation of a nuclear blast, and the method for the testing of the propagation of gamma rays in the air, as well as many others. Both the current state of research and the developmental tendencies in the field of protection against weapons of mass destruction will remain closely connected to corresponding factors in the field of environmental protection. Specialized preparations, corresponding to the equipment and laboratory facilities, in the experimental testing grounds of the military chemical research agency, permit its active inclusion in environmental protection work. Presently, military scientists, chemists and nuclear physicists, are cooperating in work on equipment for the protection of the respiratory system (industrial masks and

respirators, filtration, ventilation and climatic equipment), protective devices for the skin and eyes, etc. Institutes are cooperating in research on the dispersal of harmful substances in the air and on forecasting the damaging effects of tanks and equipment containing substances harmful to humans and the environment. The chemical forces serve the needs of the country by providing not only a research base, but also the technical means and the training of personnel. They aid in meeting the special and immediate needs of preventing or diminishing damage caused by alarm and dangerous occurrences. Subunits of the chemical forces have actively participated in controlling the eruption of salt springs caused by well drilling, they have removed the causes for alarm in chemical factories and have detected sources of river pollution. Other services rendered to the country include the liquidation of poison reserves after World War II, of cyanide salts and refuse from its production.

The need to possess operational rescue groups, well equipped with modern technology and excellently trained, will continue in proportion to the further, revolutionary growth of the industrial potential of Poland, independently of the level of security from the effects of alarm and other occurrences. The chemical forces will always be such a reserve service for the country.

8.1 THE EQUIPMENT OF THE HEALTH SERVICES

Immediately after the end of military actions military health services were equipped with material delivered from the Soviet Union and a small quantity of captured material. This equipment included: operating rooms and first-aid stations set up in tents, single bulb operating lights, autoclaves heated by primus stoves, ADU baths installed on a GAZ-A-A motor vehicle, the Cliver-Brook bath chamber, a canvas chamber for steam disinfecting, etc.

This equipment, used during the war, became obsolete after a few years, both in physical and moral terms. Domestic industry, however, destroyed during war, could not initially meet the growing needs in the field of the modernization and production of medical equipment. The army was supplied with new medical equipment, consequently, from imports predominately originating from the Soviet Union and other countries.

Visible progress in the modernization and technical production of the health services began to be noted only at the beginning of the 1950's. This period was preceded by analyses and studies concerning the adaptation of medical equipment to the directions of the development of general military equipment and preparations for the production of equipment based on some domestic designs and licensed documentation. As a result of these studies and achieved production experiences, Polish industry planned the production of:
--typical and adapted systems for the transport and rapid evacuation of the wounded;

- mobile technical systems for providing qualified medical aid to the ill and wounded;
- highly efficient equipment for field hospitals;
- special equipment for the prevention of sanitary losses under conditions of the use of weapons of mass destruction.

The realization of the above mentioned aspirations was made possible thanks to the aid of and close cooperation with the health services of the armies of the member states of the Warsaw Pact, which began the modernization of their own technical equipment at this same time, and thanks to the expansion of Polish industry, scientific-technical agencies and cooperation with interested branches of the national economy. The result of these activities was the introduction of modern medical field equipment into the army in the middle of the 1950's. At this time the production was begun of six-person ambulances, built on the chassis of the Lublin and Gaz-63, adapted for the transport of the wounded under field and garrison conditions. Disinfecting bath equipment, built on the chassis of the same vehicles, and other similar equipment in one-axled trailers, were produced later. This equipment, quite modern for its time, was intended for the carrying out of anti-epidemic measures in centers for infectious illnesses, for the disinfecting or delousing of clothing and for bathing under field conditions. This equipment could also serve to disinfect clothing when some types of battlefield poisons were used, and to deactivate individuals exposed to radioactivity.

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Further, visible progress in the technical field of the military health service followed with the development of medical equipment and apparatuses, adapted for use under field conditions (x-ray devices, autoclaves, refrigerators, operating tables, first aid stations, etc.). The development of motor vehicle technology also had a great impact on medical equipment. Especially important were developments

in chassis, auto bodies and trailers. These provided a base for structures of medical field equipment, thus increasing in a significant manner the mobility and maneuverability of the subdivisions and units of the health services.

Using the design of the Star 25 LS motor vehicle, together with the 116 type body and a domestically designed x-ray machine, a new, fully equipped mobile x-ray device was constructed for the needs of the health services. Moreover, the first autolaboratories, mobile first aid stations and operating rooms, and prototype of a field blood transfusion station were all based on this motor vehicle.

The proper conditions, which permitted the production of modern field equipment for the health services, existed only at the beginning of the 1960's. The Star-660 motor vehicle and the 117 AUM standardized body, along with the 250 body, were used for modernized medical equipment.

In this period totally new equipment and field objects for the health services appeared, mounted on open-terrain transports. The new equipment, mounted on these vehicles, created working conditions and quality medical services for the ill and wounded, which approached those found in hospitals and clinics. Of this equipment, we must mention modernized first aid stations, operating units, blood transfusion stations and universal autolaboratories.

The first aid station, mounted on the chassis of the Star-660 and 117 AUM body, was intended for the issuance of qualified medical aid to the wounded and ill under field conditions. Additional elements of this station included two tents connected directly to the auto body's side

walls, in which preparatory and post-operative activities were performed.

The first aid station's basic equipment included a moveable operating table, a four-bulb shadeless lamp, an artificial respirator, airconditioning, necessary medicines, first aid materials and surgical implements. This station was adapted for operation in any terrain or climate. Slight design and equipment modifications in this station allowed it to be used as a pre-operative station, placed within the framework of a field operating unit.

The mobile operating station, the basic element of the operating unit, was mounted inside the 250 truck body and had two tents attached to the body's side walls. This unit was intended for the performance of all types of surgical measures under field conditions and in various climates. It was equipped with two operating tables, facilitating the concurrent work of two operating teams. The joining of the pre-operative room with the operating station by means of a special connector permitted the free transport of the wounded from one room to another. The unit's equipping with the required first aid materials, surgical implements, medicine and combustion or electrical heaters allowed it to independently fulfill its task in any area.

The liquid sterilizer mounted on the the Star 660 motor vehicle with a 117 AUM body make up one of the most essential elements of the equipment of modern field hospitals. The sterilizer, in connection with distillation-sterilization equipment placed in a 1.5 ton trailer, can produce blood plasma under any conditions using the thermal method (with regard to distilled water) or the athermal method by means of demineralization and sterilized filtration.

Special refrigeration and isothermal containers are used for the field transport and storage of blood reserves and blood plasma. The ice, necessary for this, is produced in shells or briquettes in portable ice makers, which are included in all blood transfusion stations.

Universal autolaboratories, mounted on the Star 660 with the 117 AUM body, are used for the carrying out of necessary analytical tests under field conditions. These laboratories, depending on their equipment, can be transformed into special radiological-toxicological, sanitary-epidemiological, sanitary-hygienic, analytical and clinical laboratories. Special systems, worked out for these laboratories, and their supplying with the necessary equipment, ensure the performance of complete medical diagnostic testing. The military health services possess important stations for the production of liquid oxygen and for its gasification under field conditions. This is necessary for the supplying of operative units with the oxygen needed for the saving of human lives.

Airplanes, helicopters, passenger trains, heavy trucks and buses have been adapted to supplement the specialized medical field equipment as systems for the evacuation and transport of the ill and wounded. The designs used for the adapted equipment ensure the maximum utilization of transport systems and standardized sanitary carriers.

The equipment of the military health services, characterized above, make up the basic technical equipment of the medical units. They are supplemented with electromedical instruments, used in reanimation measures, diagnosis and intensive care. These specialized devices

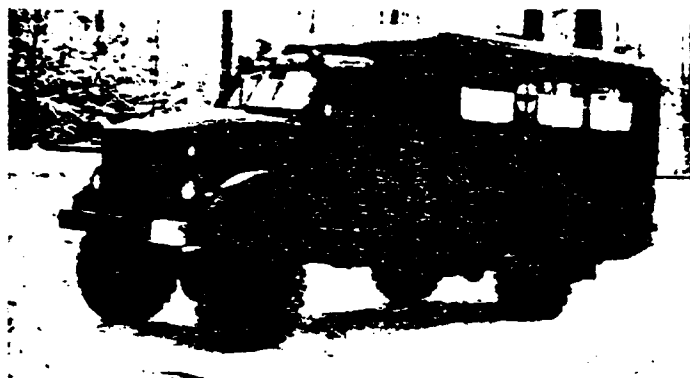
are used, for the most part, under difficult climatic and operative conditions.

The equipment of the military health services mentioned above, although illustrative of the process of the service's development over the last thirty years, is not exhaustive and does not include the much improved versions of this equipment. Work planned for this field will touch upon the further development of medical technology, and especially the improvement of equipment intended for the evacuation and transport of the wounded, faster first aid, diagnosis, therapy and rehabilitation.



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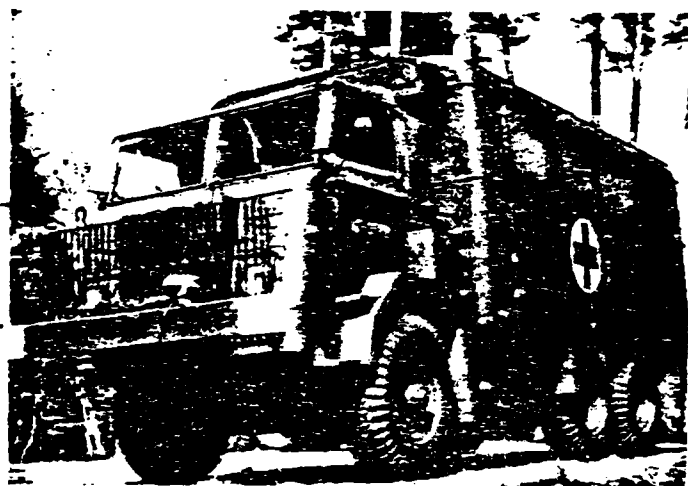
The UAZ-452A four-person ambulance



The six-person sanitary ambulance
on the chassis of the GAZ-63



An operative unit on the Star-25LS
with the 116 body



A first aid station on the Star-660
truck with the 117 AUM body



An operative station on the 250 body

8.2 EQUIPMENT FOR THE FUEL AND LUBRICANTS SERVICES (MPS)

The basic task of the MPS service is to supply the army with fuel and lubricants with the appropriate physiochemical properties and required purity. From these basic functions arise the two general directions of the technical activities of this service, of which one is the design and production of fuel and lubricants adapted to technical military requirements, and the second the production of highly efficient equipment for the transport, storage and distribution of these products.

In the first years after liberation the main task of the MPS service was concentrated above all around matters connected to the terminal supply of military units. Equipment, which was far from new or modern, was used for this task. Fuel was transported most frequently in 200-liter tanks, although, in fact the number of self-propelled cisterns never exceeded several tens. Simple equipment, such as hand pumps, buckets and funnels, were usually used for the distribution of fuel.

In later years the tasks of the MPS service grew in proportion to the development of military technology. The reconstructed Polish industry still could not undertake the production of the needed cisterns or pumps. The cistern production of the Soviet Union saved the situation, especially with the deliveries of the ZIS-5, GAZA-A and later the ZIS-150 cistern and the PD-10 and WS-65 pumps. As a supplemental cistern the ZIS-150 was adapted to Polish conditions and had a capacity of 3000 liters. It was placed on a two-axle trailer, equipped with a hand pump, a simplified distribution hitch and a system of vacuum conduits. A unit of these cisterns could transport around 7 thousand liters of fuel.

The first self-propelled cistern produced in Poland was built on the chassis of the Star-66, whose serial production was begun in the 1960's. This cistern with a capacity of 4500 liters constituted expressed progress in relation to imported cisterns; it was simple and easy to operate, and completely Polish built, which simplified repair and the supply of replacement parts.

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The dynamic development of general military technology, and especially of aircraft, armor and motorized equipment, led to an increased need for the supply of better fuel, oil and lubricants. Under these conditions the domestic production of PS-2 airplane fuel and Selektol 9S all season oil, which after its introduction into universal use in the army and national economy contributed to the elimination of labor consuming measures connected to the seasonal reconditioning of motorized equipment and to lessening its cost, was initiated by the MPS service. Other achievements in this field include the production by the MPS service of Antykol 8 gear-conditioning oil, which made possible the utilization of reserve military motorized equipment without first reconditioning it. This oil found broad application in the national economy.

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The continuous supplying of military units with new equipment, and especially their supplying with motorized equipment, led to an increased need for an assortment of fuels and lubricants. Under these conditions new tasks in the field of producing modern devices designated for the storing and distribution of these materials were assigned to the MPS service. Not only did steel tanks with a capacity of 10 and 20 m³ meet these needs, but so did fuel cisterns with pumps capable of putting out 200 l/min.

A new development in the field of equipment for the transport and

distribution of fuel and lubricants is the A-80 distributor cistern, mounted on the Zubr motor vehicle. These cisterns, with a capacity of 8000 l, have a much improved design in comparison with those mounted on the Star-669. Moreover, they are, in an expressed manner, an improvement over the previous supply system of petroleum products. A supplement to this cistern is the fuel cistern mounted on a two-axled trailer with a capacity of 12,000 l. The distribution hitch of this cistern is adapted for both the intake and feed of fuel, with the use of the A-80 pump mechanism.

The next new equipment intended for the transport and distribution of aircraft fuel is a distribution cistern mounted on the Jelcz-315 motor vehicle with a capacity of 7500 l and an output of 600 l/min. Special control devices were included in this cistern, allowing the fast and very precise detection of all the pollutants which could appear in the transported fuel.

This equipment was anticipated also for other distributors, used especially in aviation, where pilots demand this modern technology.

All fuel cisterns and distributors produced for the needs of the army are standardized within the necessary range with those produced for the national economy. Under these conditions, in times of need, there exists the possibility of using civilian cisterns in the army, as well as the transferal to the civilian economy, mainly the Commercial Center for Oil Industry, of military transport-distribution equipment. ²⁴³

A separate group of equipment intended for transport and distribution are soft steel pipelines with various diameters. The production of

this equipment and its introduction into the military, together with high output pumps and soft containers mechanized to a high degree the system of fuel transport and distribution under both field and garrison conditions. Used in complete systems, soft containers with large and medium capacities are intended mainly for the organization of field fuel depots. These containers, and especially containers with smaller capacities, besides their basic function, can also serve for the the transport of fuel with the use of a two-axled trailer or transport vehicle, which lessens the need for cistern vehicles. Mobile analytical laboratories, mounted on motor vehicles, as well as portable laboratories produced in the form of pallet units, were intended for the control and performance of the necessary analysis of petroleum products under field conditions. The operation of analytical elements, based on these laboratories, guarantee the supply of fuel with the necessary quality and purity to special types of battlefield equipment.

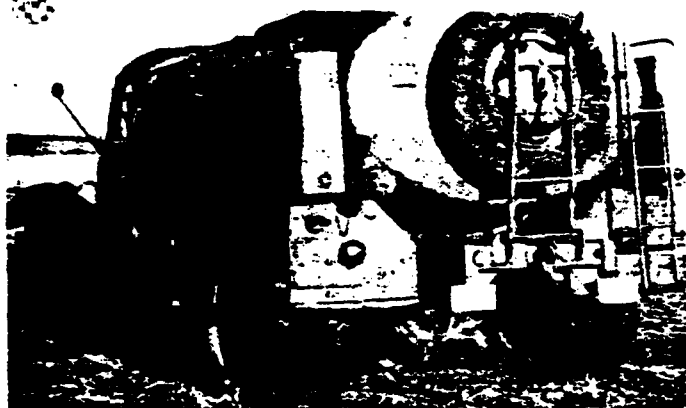
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Equipment intended for the transport, storage and distribution of solid rocket fuel and lubricants, together with the equipping of our army with rocket weapons, has changed the face of the equipment in the MPS service. The first exemplar of cisterns and containers intended for the transport and storage of solid rocket propellants was imported, but was later produced by Polish industry.

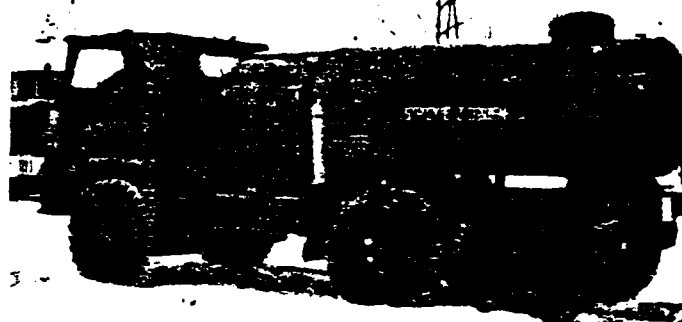
The design of the equipment of the MPS service presently ensures the adequate supply of the army with liquid fuels and lubricants. However, the continuous development of equipment and weapons in the airforce, the navy and army requires the constant improvement of this equipment and its adaptation to new demands and new technology. Further work in this field is aimed at the designing of improved fuel and lubricants, highly efficient filtration equipment, modernized pipeline systems and larger and more efficient fuel and oil distributors.

distributers.

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A gasoline cistern with a capacity of 4000 liters mounted on a ZIS-150 truck



A distribution cistern mounted on a Star-660 truck



The A-80 distribution cistern mounted on a Zubr truck



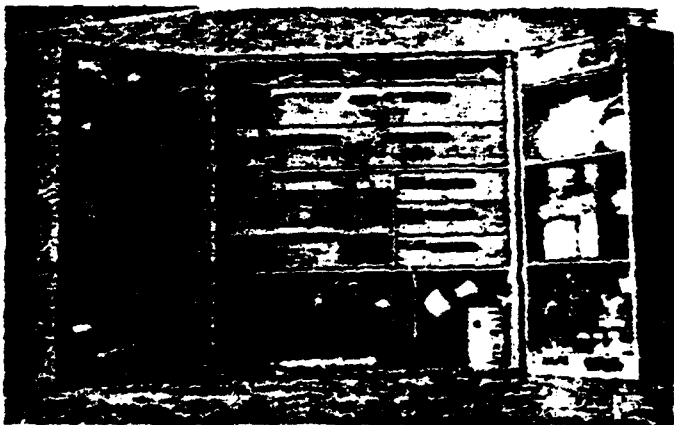
The CD-7.5 distribution cistern mounted on the JELCZ-315 truck



The ZGP-25 liquid fuel soft container



The ZGT-4 soft container filled with fuel during its loading onto a truck



A MPS laboratory--gap-powered unit

8.3 THE EQUIPMENT OF THE MILITARY COMMUNICATIONS SERVICE

In the initial period of the existence of the Polish People's Army, 244
transportation units performed communication tasks in the field of
restoring and building bridges, railroad tracks and carriageable
roads with the use of equipment received from the USSR. This
equipment was intended predominately for ground work (graders and
scarifiers, bulldozers) and equipment for pile-driving and for
woodworking (frame-saws). The other devices used, usually attached
to manual or line steering, consisted of light equipment, which could
be used only on a limited front. Consequently, effectiveness was
not too high. In later years this equipment was modernized in order
to elevate its technical-exploitative parameters and was adapted to
the new tasks placed in front of military communications units.
During the training of soldiers in the intensive use of equipment,
these devices became severely worn and had to be supplemented with
domestically produced or imported materials. The first period based 245
on domestic production saw the manufacture, above all, of mechanical
equipment with manual steering and trailer roadway devices. Wooden
or steel Bailey bridge structures were predominately used in bridge
construction.

The further development of road-bridge equipment arose mainly from
the growing demands in the field of the communication security of
operating armies, and especially the security of the required tempo of
the material supply, and therefore, the building and reconstruction
of roads, paths and bridges.

A result of these demands was the full modernization of the Bailey
roadway bridge and its adaptation to the transit of heavy tracked
vehicles. The MS-54 sectional roadway bridge with two lanes was

designed at this same time and the railroad forces were supplied with heavy sectional bridges. Excavators, graders, scarifiers and bulldozers with their own drive and propulsion system made up the equipment used for road work. The majority of this equipment had hydraulic steering.

Modern pile-drivers and gas-driven hammers were used for setting piles and electric saws and the GKT-60 frame-saw was used for forest labor and woodworking. With the building and reconstruction of railroad tracks gantry cranes, railroad cars and electrical field power plants together with accessories were used in the first period.

Special platforms, staff wagons, bath wagons, laundries, repair wagons, kitchen wagons, etc. were produced to secure the transport of the railroad forces, military equipment and supplies.

The dynamic development of roadway and railroad equipment, although characterized by many different directions, did not meet the growing needs of the military. New types of specialized equipment and machinery systems with a modern design and greater reliability, had to be supplied in a period of changing conditions. Scientific-research efforts had to intensify in the field of the modernization of communications equipment and the development of new designs, which considered the possibilities of the domestic material and productive base. The result of these efforts was a new sectional roadway bridge for crossing wide water obstacles and a viaduct, which made possible a two-level road crossing system. Polish produced railroad palisades, the W-2 pontoon bridge system for the transport of heavy battlefield equipment, a floating railroad bridge and sectional steel supports for railroad bridges were introduced into the army at this time.

Introduced at the same time with new roadway-bridge equipment was machinery for the mechanization of road and bridge work. This included: Polish produced modern railroad gantries, winches for the Star-660 truck, mechanized units for the demolition and setting-up of railroad lines, light and heavy base tampers and electrical devices for cutting track, drilling , screw turners, etc.

Prefabricated reinforced concrete piles and steel pipe, designed in conjunction with civilian industry, was used for the construction of bridge supports. Special pile-drivers with propulsion units for heavy air and gas hammers were designed for their installation.

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Thanks to the use of the above equipment the speed of the building and restoration of railroad lines, road and bridges was increased several times. Many projects, realized to the benefit of the national economy, served as a testing ground for practical activity. These projects included the construction of the railroad bridge near Malkina, the construction of the roadway bridge in Przemyśl, and the transfer of an excavator weighing 1300 tons over Lake Goclawskie. The military communications units, which participated in these actions, solved a series of problems of an organizational-technical and technological nature in the field of the rapid building and reconstruction of bridges, roads and railroad lines.

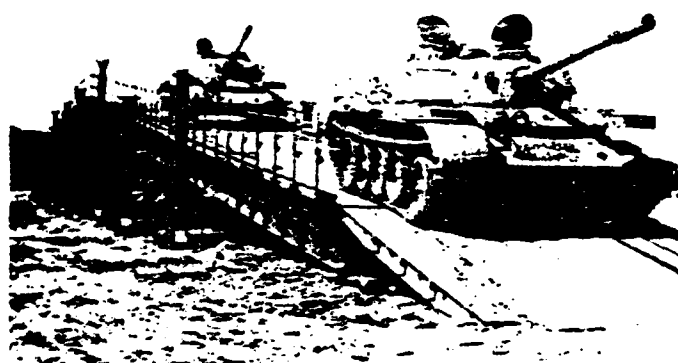
The equipment supplied to military communications units facilitated the performance of the all the tasks placed to these forces. This did not, however, prevent this equipment's further improvement and adaptation for new tasks. The work planned for this period anticipates the designing of new bridge structures (the broadening of the application of sectional roadway bridge structures and viaducts), the designing of improved bridge supports and cranes and the equipping

of railroad-road units with instruments and machinery systems with greater efficiency and carrying capacity.



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A fragment of a railroad bridge structure



A roadway viaduct (general view)

8.4 THE EQUIPMENT OF THE CATERING SERVICES

The equipment of the catering services is intended for the providing of food to the army under field and garrison conditions. In the initial period of the Polish People's Army's existence, KP-320 field kitchens with a boiler capacity of 320 l were used to feed the army under field conditions. These were improved versions of horse-drawn kitchens, which were developed by the prewar Technical Commissariat Institute. These kitchens were supplemented with the KP-42 M Soviet one-boiler field kitchen or with 150 and 200 l capacity kitchens, which, with regard to their design, constituted a modification of the KP-320. These kitchens allowed the preparation of hot meals for 70 to 200 people. Cases for the preparation of food were used for the preparation of hot meals for smaller groups (around 20 persons). Russian produced thermoses with a capacity of 12 and 24 l were used for the transport and short-term storage of meals. Similar field kitchen equipment basically did not differ from that generally used.

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From among the specialized equipment intended for the preparation of edible materials under field conditions, the catering services possessed field bakeries with KPN ovens obtained from the Soviet Union, and later produced in Poland on the basis of licensed documentation. The sifting of flour, the production of dough, etc. were all performed manually in such bakeries with the use of simple implements. Very simple equipment (tripods, pulleys, tanks, etc.) were also used for the butchering of animals.

This equipment became much less suitable to the above mentioned conditions as general military equipment developed and the maneuverability of armies grew. In this situation the catering services began to design new types of field kitchens, which would

guarantee the provisioning of the army, operating operating under various conditions. With the improvement of old equipment and the designing of new materials, special consideration was turned to its adaptation to the perspective organizational structure of the army and its supplying and operational conditions. As a result of these undertakings the KP-340 field kitchen was designed, which was mounted on a double-axle trailer with independent suspension. This considerably improved the new kitchen's traction and functional properties. In times of need the body of this kitchen could be quickly disconnected from the trailer and used as a kitchen in a railroad wagon, on a truck, landing ship, etc. The freed undercarriage of the KP-340 kitchen could also be used for other purposes, for ex. the transport of water after loading it in its containers. The boilers of the KP-340 kitchen were made from stainless steel and had glycerine covers, which allowed the preparation of food during the kitchen's transport or towing and kept the meals hot during winter (without needing to keep the oven on) even for several hours. The capacity and number of boilers in the KP-340 kitchen allowed the preparation of 3 meals a day for over 150 persons.

Field messes, consisting of kitchen-vehicles equipped with typical bodies on the chassis of the Star 660 truck and two-axle trailers, in which tents, tables, stools, etc. were transported, were used to feed cadres under field conditions. Kitchen-vehicles made up the basic element of field messes and were equipped with two kitchen centers, cabinets (for food, equipment and tableware), refrigerators, water containers, water installations and other necessary equipment at hand.

For longer stays the field mess operates in a spread out manner: tents are connected to the truck in a permanent manner, in which are found: a canteen, buffet and store. The mess can prepare 3 meals a

day for around 120 people, and, depending upon the needs of the situation, can increase that number to around 170, using the buffet tent as a space to feed personnel.

The Star-Mielec refrigerator truck with a carrying capacity of 2.5 tons, designed jointly with the civilian economy, is used for the short-term storage and transport of rapidly perishable foodstuffs.

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Cisterns, mounted on Star 25 Z trucks, which possess isothermal aluminum containers with a capacity of 3000 l and mechanical water pumps, are used for the transport and storage of water. The pumps allow the containers to be rapidly filled and emptied. In special cases, water from these cisterns can be used to extinguish fires and to make ice. Water cisterns in two-axle trailers with 3000 l capacities, water containers with 500 l capacities, adapted for transport in the KP-340 field kitchen's undercarriage, and soft containers with capacities of 10, 100, 300, 1000 and 5000 l make up the auxiliary pieces for water trucks.

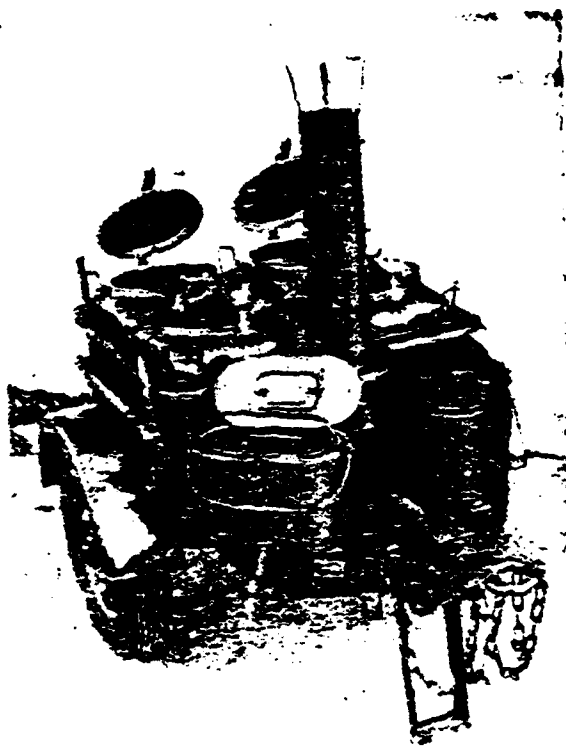
Equipment intended for the preparation of foodstuffs under field conditions are totally new in the catering services. A representative of this equipment is the mobile unit for the preparation and baking of bread during a forced march. This unit consists of a truck with the 117 M type body, in which are installed: dough mixing devices, flour sifters, flour containers, current generating devices, water installations together with water containers, pumps and water heaters. Auxiliary elements include: baking ovens with rotors, mounted in two-axle trailers and equipped with oil burners and a bread delivery vehicle, in which 3000 kg of bread in suitable containers can be transported.

A field slaughter-house is used for the butchering of animals and the production of meat products. It consists of a system of special equipment, including:

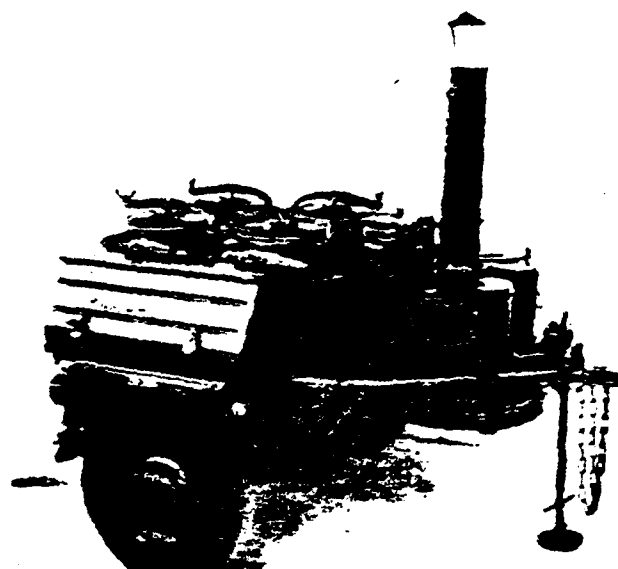
- the slaughter post, composed of the slaughter tent, together with the accessories necessary for killing the animal, skinning, scalding, cleaning, halving and quartering it and processing its intestines;
- a cooler tent serving for the cooling of meat after butchering;
- a water supply trailer for the supplying of water for scalding and cleaning;
- a butcher station with the accessories necessary for the preparation and production of meat products (field kitchens, smokers, stuffers, meat grinders, etc.);
- a meat storage station made up of an air compressor, pressurized containers, containers to prevent spoilage, feed devices, etc.

The above mentioned equipment is supplemented with catering systems, adapted to the needs of provisioning the soldiers of various forces and services, and to the needs of contemporary warfare.

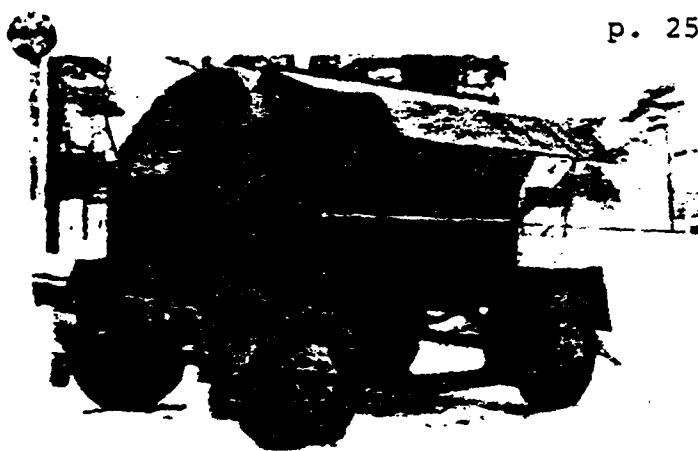
Technical and technological developments in the catering services, although sufficient to meet present needs, must be improved when viewed from a future perspective. The greater maneuverability of this equipment, an increase in its output and its adaptation to changing requirements in the field of provisioning the army under field conditions are the goals of the improvements.



The KP-320 field kitchen



The KP-340 field kitchen



A bakery oven on a two-axle trailer



A field slaughter-house--an general view

8.5 THE TECHNICAL EQUIPMENT OF THE QUARTERMASTER SERVICES

The dominant element in the technical problems of the quartermaster service, from the point of view of the tasks of this service, are military uniforms and their accessories. The technical field equipment of this service is mainly intended for bivouacking and the performance of measures connected with the securing of required hygienic conditions.

The first examples of the uniforms and accessories of the Polish People's Army were based on designs from before 1939. These products underwent modification and continuous improvement in proportion to the increased mechanization of military units and their equipping with new types of weapons, and also in proportion to new methods of training and education. New uniforms were very functional, hygienic, aesthetic and adapted to the changing conditions of the service and work of soldiers in various types of forces and services. The production of this equipment was undertaken with regard to the factual possibilities of national resources and production, as well as to the high demands of modern military tactics and techniques.

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The further improvement of the aesthetics, quality and functionability of military clothing and accessories, as well as their adaptation to constantly changing conditions of training and use, is one of the basic and permanent tasks of the quartermaster service on all levels of command.

Curved segment tents, which, depending on their designation, have various accessories, are mainly intended for the army's field bivouacking. Pelerine tents, which are standard in the equipment of

every soldier and can make rather comfortable tents for two people when two are joined together, can also be used for the army's field bivouacking. Moreover, small, six person tents, warmed by liquid fuel heaters, are intended for lower grade commanders, not accommodated in special motor vehicles. Gas-powered cobbler-tailor workshops, adapted for transport are intended for the repair of uniforms, accessories and footwear under field conditions. Cobbler-tailor workshops, mounted in the bodies of special, large-capacity trucks, were designed independently of these above mentioned workshops.

In the first years of the existence of the Polish People's Army simple and universally used equipment was designated for the washing of underwear and uniforms. These included: wash-tubs, wringers, continuously heated boilers, etc. The washed objects were then dried in the open air or inside tents. This type of equipment did not correspond to new tactical and technical requirements, and above all, did not provide the required efficiency, maneuverability and sanitary-hygenic conditions.

Consequently, two different equipment systems were designed for the washing of underwear and uniforms under field conditions. These were 254 water and chemical cleaning systems.

The first mobile laundry unit for water washing was introduced in the 1950's. The basic elements of this system were a laundry vehicle, equipment for the production of steam and current-generating units, which fed the washing machines with electrical energy. The first laundry vehicle was built on the chassis of a Star 25 LS truck with a 116 type body. This laundry was equipped with:
--two washing machines;

--one wringer for wringing our washed underwear;
--one dryer.

At first, the steam boilers of the disinfecting baths equipment, mounted in single-axle trailers, were used to heat the laundries' tubs and to dry the wringed-out laundry.

Modernized water laundries, produced at the beginning of the 1950's, were built on the undercarriages of open-terrain vehicles with standardized 117 M bodies. Fifty kilogram washing machines replaced twenty-five kilogram machines within the framework of the program to improve water washing machines. More efficient drying equipment was used at the same time. The use of new steam generators instead of the boilers utilized in disinfecting baths aided greatly in the obtaining of increased efficiency.

The use of fast-acting steam generators in field laundry units increased the efficiency of these laundries, since the time necessary to heat the tubs and dry the washed laundry was lessened.

Mobile chemical laundries were used to clean uniforms and other protective clothing in the field. These laundries were mounted on the undercarriages of open-terrain vehicles with standardized truck bodies.

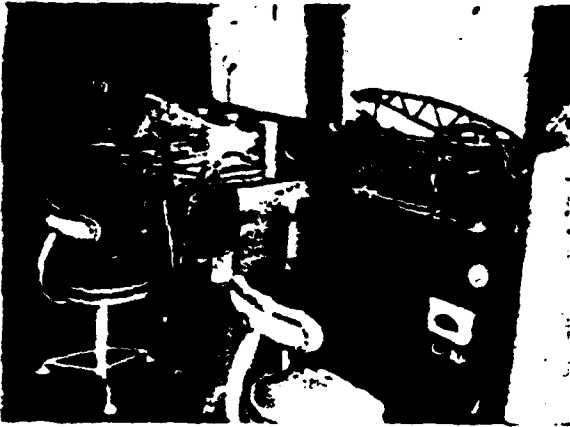
Water and chemical laundries were adapted to the full production cycle in any climate, with regard to the deactivation of the washed objects.

Tent baths and baths in special vehicles were used for human bathing in the field. Tent baths were organized in segment tents, in which shower units were mounted, fed with hot water by heating units. These heating units could also be used to feed vehicular baths with hot water. The basic element of the heating unit was a boiler heated by liquid fuel or a gas engine, which drove a water pump and air blower. The output of this device, depending on the temperature of the water transferred into the reservoirs (tubs), amounted to several thousand liters per hour. This unit could be used practically everywhere, where hot water was needed.

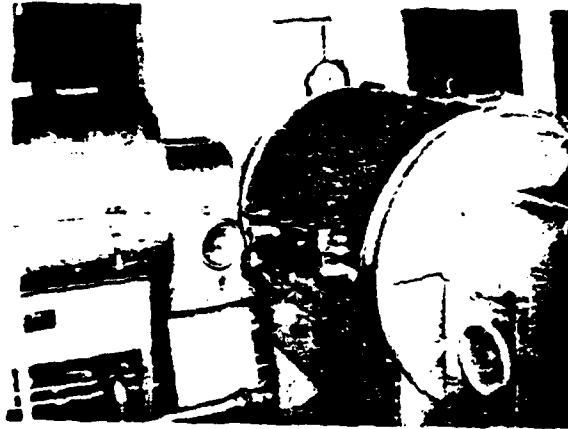
The vehicular baths were mounted in the first version on the undercarriages of Star 25 LS trucks with 116 type bodies. The output of these baths, while maintaining an established bath cycle, is many times greater in summer than in winter.

New designs of field baths were made for distributive bodies, mounted on the undercarriages of Star 660 trucks. At the same time the equipment operating these baths secure the drying of uniforms or their disinfection.

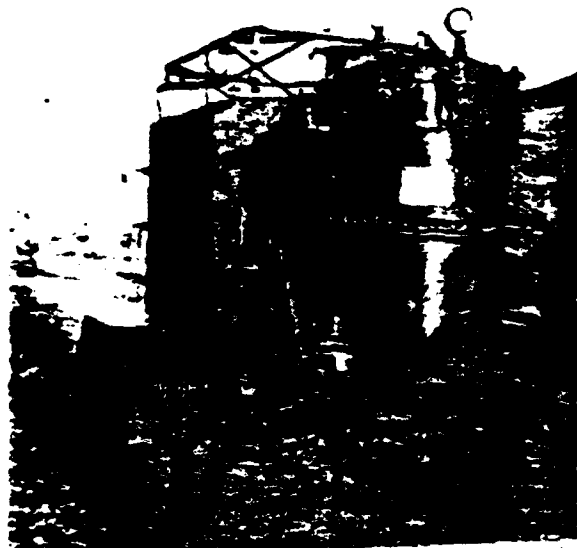
The field equipment of the quartermaster service presented above corresponds for the most part to actual requirements and allows the maintenance of the corresponding sanitary-hygenic state among soldiers on maneuvers or in training.



A shot inside a cobbler workshop in a truck body



Laundry equipment mounted inside a 116 type body



Disinfesting-bath equipment on a trailer--a general view



A water laundry vehicle on the undercarriage of the Star-660 truck with a 117 type body

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A field bath on the undercarriage of the Star-660 truck with a 250 type body



A chemical laundry vehicle on the undercarriage of the Star-660 truck, rear view

8.6 THE EQUIPMENT OF THE BILLETING SERVICES AND MILITARY ARCHITECTS

The technical activity of the billeting services and architects is multiprofiled. Its chief direction concerns the development and technical progress of military architecture. The first development in this field was aimed at the creation for units of convivial conditions in order to gain battle readiness and the best possible living, training, rest and cultural conditions. The technical-architectural problem in this period was concentrated on the tasks connected with the reconstruction of barracks, roads, electrical networks, etc.

New architectural designs and developments appeared at the moment that the building of military objects was undertaken. These were based initially on partially industrialized technology, and later on fully industrialized, architectural technology. Technical achievements of this period include the designing of standardized military objects, such as soldier's canteens, workshops, garages, barracks, etc. These developments were grouped into the "The Architectural Catalog of the Ministry for National Defense", into the "Technical Projects Standards" and the "Technical Conditions of Projects", used in the practical activity of project bureaus and working units.

Technical designs from the field of architecture were supplemented with those from the field of the supplying of military building materials. Especially worthwhile were designs of portable equipment intended for the billeting of military engineering units and for the securing of their living conditions (trailer kitchens, lighting, canteens, etc.) Other developments from this field included bath-houses, umbrella roofs, sewage channels, etc.

Steel structures deserving of attention include domestically designed large roofs, characterized by the small consumption of steel per meter, the small number of carrying columns which support the structure, etc.

The presented structural developments concern only one direction of the technical activity of this service. Developments, intended for the maintenance of military objects in a state of full readiness and functional effectiveness, represented a large part of the equipment. Such equipment deserving of attention include:

--vehicles-workshops and equipment systems for the conservation of sewage systems, transported in specially adapted Zuk service vehicles or on single-axle trailers with a truck body;

--equipment for the protection from fire of objects and military property. In this group were used domestically designed 4-cylinder fire extinguisher system and equipment used in the civilian economy; they were mounted on either the SBA-200/16 or SBM-2000/8 motor vehicle.

A separate part of the technical equipment of the billeting services and architects is made up of billeting-accomodation equipment, and therefore, all types of furniture, adapted to barracks and field condtions. New architectural developments, its aesthetics, and even new requirements in the field of military billeting, have led to the appearance of new very aesthetic and functional equipment in soldiers' quarters, canteens, club rooms, etc. Similar changes have taken place in equipment intended for the work and rest of the staff in the field. Equipment made of metal elements, resistant to changes in temperature and moisture, dominated these devices.

The equipment and products of the billeting services, intended for the

security and servicing of the army under both garrison and field conditions, are for the most part completely suited for use in individual sectors of the national economy. This is verified by the fact that many types of billeting equipment have direct application in the national economy, and are used as the occasion warrents in various economic undertakings.

The linking of military technical developments with the needs and requirements of the national economy and the reverse is creating the conditions for the rotation of military technical equipment and meeting the needs necessary for mobilizing and preparing the national economy for cooperation with the army in threatened fields. The fact is, based on this activity, that the problem of national defense is a matter for the entire country and must be considered and realized within the framework of the nation's total defense.

9. THE ROLE OF MILITARY SCIENTIFIC-RESEARCH AGENCIES IN THE DEVELOPMENT OF THE BASIC SCIENCES

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9.1 INITIAL CONSIDERATIONS

Basic research was necessary to maintain a high level of military technology and the rapid tempo of its development. Research, carried out in the field of such sciences as physics, chemistry, electronics, cybernetics, mathematics, aerodynamics etc., was essential in applications for military needs. The progress achieved in these fields included solutions for emerging problems of military technology and the creation of new operational methods and new types of military equipment.

The basis of military research practice is that fundamental research is always understood as the point of departure for applied research, even if it should concern aspects of cognitive decision making. Independent of the above, under the concept of basic research is understood not only purely cognitive research, but also applicative work, which makes up an essential element of new physical qualities from the point of view of a given application.

Developmental work is performed with the full concentration of forces and resources on the highest level of world scientific-technical progress, eliminating the possibility of the appearance of a technical-technological gap in the equipping of our army.

For many years, recognizing the growing importance of basic research in the development of defensive potential, the Polish People's Army,

relative to the needs and capabilities of our country and its role in the camp of socialist nations, is developing research on the broadest scale. Military academies and research institutes and centers are serving these goals.

The conditions of the harmonious and rapid development of the nation's science, technology and economy require that the development of military science and technology be closely connected to it. This also concerns basic research. Therefore, the defensive needs of the country have been considered in the general national plans for the development of scientific research. Military scientific-research agencies, consequently, are playing a role in the realization of a series of basic problems, cooperating with the Polish Academy of Sciences and other civilian scientific institutions.

The basic sciences are a broad concept, which encompasses many diverse scientific disciplines. The progress of the Polish People's Army in the field of basic research in the last 30 years has been treated with regard to military technology in the following scientific directions:

- 1) research in the field of electronics;
- 2) research in the field of cybernetics, utilization systems and reliability; 262
- 3) research in the field of mechanics;
- 4) research in the field of aerodynamics, aircraft mechanics, aero-elasticity, and aircraft and rocket design;
- 5) research in the field of mechanical vehicles and robot machines;
- 6) research in the field of military engineering and geodesy;
- 7) research in the field of armament technology.

9.2 RESEARCH IN THE FIELD OF ELECTRONICS

In recent years an unusually rapid development of technology has been noted. The science, however, which is the basis of this development, whose tempo of change is the greatest-- One only has to remember that we passed through only from the birth of electrical lamps to transistors, and now we are entering into integrated systems, which are completely changing the face of electronics.

The development of other scientific disciplines are also being accelerated by electronic progress, and especially new, automated devices, an entire gamut of information and mechanical engineering, in general the entire infrastructure of contemporary technology.

The role of electronics in the development of modern technology is unusually essential. Examples of this discipline, which exist only, or chiefly, in military applications include: --radar--using the propagation of electromagnetic waves for determining the position of objects; --telecommunications--which form a military system of communication networks and means with specifications and parameters higher than in civilian applications.

The existence and development of these two disciplines would not have been possible without basic research, which was performed in divisions subordinated to the Ministry of National Defense. The following must be included among the important disciplines: --quantum electronics, whose appearance and development in our country is closely connected to the army, and especially to the Military Technical Academy (WAT); the first lasers were developed here; WAT won the deserved function as the coordinator of this discipline on the national scale;

--solid state electronics--a modern discipline, which uses physical phenomena in solid bodies; its development has led to the designing of new devices which have conditioned the growth of miniaturization and reliability--unusually valuable characteristics in military equipment;

--microelectronics--a field whose final products are high level integration systems;

--microwave acoustics--a discipline which has been developed in our country thanks to the work of military scientists; in recent years the range of applications of this discipline has grown in the national economy, and especially in telecommunications;

--medical electronics and bionics--young disciplines, but unusually important in a period when human health care and environmental protection have become very important; the role of military electronics has contributed to modifications already in use in these disciplines.

The above mentioned disciplines are among those in which the military has played an important role. There exists many other activities, which are used directly or indirectly in other areas: in mining, energetics, the machine industry, etc.

We will deal with the significance of these disciplines and their achievements and developmental problems with special consideration of the needs of the Ministry of National Defense and the role military scientists play in them.

QUANTUM ELECTRONICS

Quantum electronics utilizes physical phenomena concurrent to the

influencing of a magnetic field with material. The result of this influencing is the possibility of producing streams of coherent beams in the range of optical waves, which, just as signals in the classical radio range, are used in various devices.

The theoretical work of many physicists lies at the base of the operation of these devices (lasers). In December 1960 the first laser with rubies as the active material was produced. In 1961 appeared the first gas laser. In 1962 beams were obtained from electroluminescent diodes.

In Poland work on lasers was begun in 1962 under the direction of Lt. Colonel Dr. Engineer Z. Puzewicz and Lt. Colonel Dr. Engineer K. Dzieciolowsky. The first gas laser in Poland was developed in 1963. Several months later a ruby laser was produced, and in 1966 a CO₂ molecular laser was developed. Argon, cadmium vapor and selenium lasers were introduced in the following years. 264

In the course of the ten years since the introduction of the first lasers, tens of different types of lasers, functioning on various wave lengths, beginning from ultraviolet, through the entire range of optical waves up to waves in the close, medium and far infrared ranges, have been designed both abroad and in Poland. High technical parameters were achieved for these beams, both with regard to the repeatability and stability of the functioning, as well as to the reliability and usage life of the device.

Thanks to the characteristic traits of laser beams such as: coherence and monochromatism, extremely small beam dispersion, the possibility of a powerful concentration, and the great power of the beams,

laser devices in the full sense of the word have become an autonomous force in fueling contemporary development in various scientific and technical fields. These traits lie at the base of the broad application of laser beams in science and technology and especially in the technological processes of industry, meteorology, the structural testing of the subtle structures of materials, communications, ranging, medicine, etc.

Military scientists are also performing research-design work on a series of devices intended for the above mentioned goals.

The results obtained from research on laser beams have allowed WAT's scientific laboratories to construct from the design and technological point of view a broad series of models used for science and industry. These devices include:

- laser microrods (in the machine industry);
- industrial molecular lasers with a continuous power of 250 W;
- micropuncture equipment;
- laser coagulaters;
- devices for spectral microanalysis;
- devices for the delimitation of straight lines;
- measurers of the parameters of a laser beam and a series of auxiliary optoelectronic systems.

The team of WAT workers was awarded the State Team Award second class in 1968 for work in this field.

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Deserving of special attention is the use of laser beams in military technology. In the Military Technical Academy, the institution responsible for the national development of quantum electronics, there was or is being produced a series of laser equipment, designed to

meet the needs of the military. The most important of these will be described below.

Devices for the direct support of military activities--a series of devices (artillery, naval, tank, aircraft, geodesic), shells and bombs, tracking instruments, radar for directing fire.

Equipment for reconnoitering needs--devices for airbased photographic reconnoitering independent of the time of day or season, instruments for the long-distance transmission of reconnoitering pictures, equipment for the oblique photographing of large areas, devices for low level air reconnoitering and the detection of small mobile targets.

Navigational equipment--devices for the measurement of the altitude and speed of aircraft, for the identifying illumination of terrain.

Military training equipment--laser tank firing simulators. This equipment allows the training of crews not only in stationary conditions, but also while on the move, that is in conditions in which the psychophysical predisposition of the training crew can be completely used.

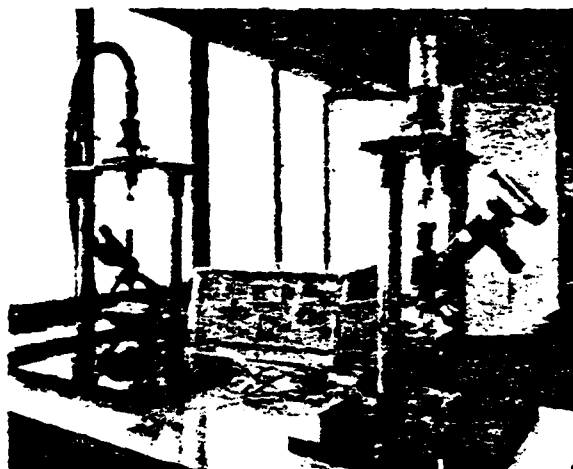
Equipment which uses holographic methods for the registration and reproduction of wave fields obtains the most complete information possible about objects which interest us. The absolutely accurate description of fields dispersed over objects is the characteristic trait of holographic registration. This results in the obtaining of three dimensional pictures with a theoretically

unlimited depth of sharpness and unlimited field of vision. It is possible, moreover, with the aid of holography to effectively code information, to store it in the form of a permanent record.

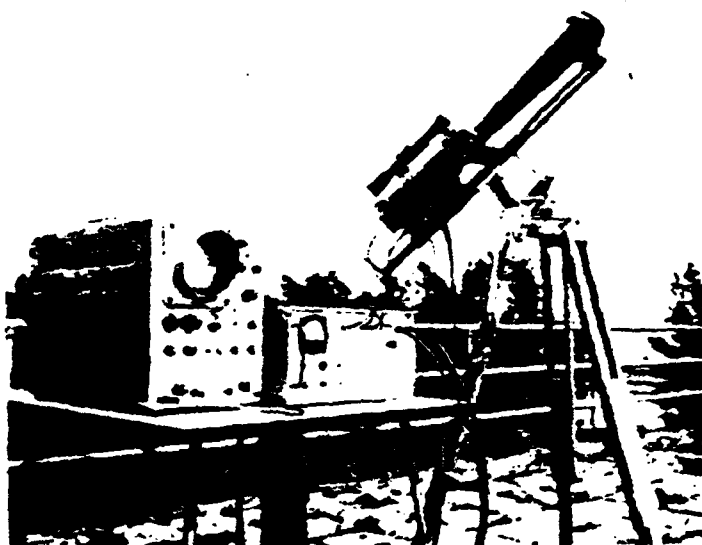
A series of experimental laser systems has also been developed, such as: laser communications, auxiliary devices used for the control and repair of military equipment in mobile and stationary workshops, etc. Parallel to work of this type, research has been undertaken in WAT on the introduction of high energy lasers, whose importance in military and industrial applications is quite essential. Presently, two directions of development can be distinguished in quantum electronics. The first is the intensive work on the raising of the reliability, effectiveness, usage life and energetic parameters of these lasers. The result of this work is the rapid development of a technology which has obtained the high quality of crystals and optical glass, the great purity of gas and other materials used in optical resonators and other types of optical elements (mirrors, laminates, prisms, lens, thin metallic or dielectric layers, etc.) adapted to reliable research on very dense laser beams. The second direction of development deals with, above all, auxiliary elements and systems such as: photodetectors of various optical wave lengths, many types of light modulators, deflectors, optical fibers, picture transformers and amplifiers, wideband electronic systems--optoelectronic measurement systems, various holographic systems, etc. Independent of the above directions lasers have found broad application in high temperature plasma research.



A solid state laser



Micropuncture equipment



Special laser equipment

SOLID STATE ELECTRONICS

The rapid development of solid state electronics became possible thanks to the tremendous progress in the technology of semiconductor, dielectrical, magnetic and superconductor materials. The manifold studying of these materials, both theoretically and experimentally, has led to discoveries of many fascinating physical properties, which in turn were used in concrete electronic devices.

The basic elements of semiconductor electronics are presently semiconductor devices. The development of semiconductor technology dates from the post-war years. In 1948 the first semiconductor triodes (transistors) appeared. In the 1950's intensive work was begun on the technology of silicon and germanium diodes and transistors. Presently, the term semiconductor device means a large group of instruments including hallotrons, thermistors, semiconductor diodes, transistors, photodiodes, phototransistors and others.

Deserving of special attention, from the point of view of application in military technology, are large frequency devices. Uncommon intensity has been devoted in recent years to their design. These devices fulfill many functions. They can be generators, amplifiers, detectors, connectors, modulators and limiters of large frequency signals.

In connection with the technology of the scaled circuitry, semiconductor elements of great frequency allow the creation of miniaturized systems of great frequency at a relatively low price. This is essential for military, aviation and astronomical technology.

The new direction in microelectronics--scaled systems of great frequency--is gradually becoming one of the most important directions of microelectronics. It is considered that in the 1970's all deck and a series of surface radar communications systems will be built exclusively on the basis of scaled microsystems.

Parallel to powerful great frequency transistors, the technology of diodes with the avalanche duplication of their charge is being intensively developed with the increase in the power of common Gunn generators and capacity generators of gallium arsinide with a limited spatial charge.

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Of the other applications of semiconductors in electronics, and especially in military electronics, we must mention infrared radiation detectors. It is also appropriate to mention such issues as heat seeking of radiation emitted by objects, communications, the detection of objects, the self-aiming of shells, infrared photography, the signalling of the presence of battlefield poisons, etc.

In WAT work has been performed since 1967 on the photoelectric properties of semiconductors and on the unusual equipment necessary for this research. A series of special vacuum instruments for the infusing and technological processing of semiconductor layers has been designed and constructed. A new model of a reflective electron microscope for the study of electrical heterogeneity on the surfaces of semiconductors (which received a prize at an international exhibition in Moscow) has been produced.

Studies have been developed on the technology of (CdHg)Te and (ZnHg)Te layers and their applications in infrared radiation detectors. Work

on infrared radiation detectors has been developed as before and presently we possess highly sensitive thin layer detectors with a range of $10.6 \mu\text{m}$ and heterobonded Ge-Si with a range of $1.06 \mu\text{m}$. With regard to the use parameters of the detector, these do not take a back seat to foreign models.

MICROELECTRONICS

Microelectronics is a field of electronics which encompasses a complex of technological and systematic problems connected to analysis, the study of properties, the design and production of electronic equipment in microminiature format, characterized by the complete or partial lack of individual (discrete) elements.

In the word microelectronics is found a reflection of two basic tendencies of modern electronics, that is integration and microminiaturization. Microelectronics has been developed in the direction of the integration of elements (scaled systems) and the integration of systems functions (functional equipment), which promises the user of the electronic equipment real advantages: improved reliability of operation, the improved quality of electrical parameters, the considerable lessening of dimensions, weight, energy consumption, a decrease in cost, etc.

The development of microelectronics, both in the initial research phase and in the production phase, was and is strongly stimulated by the specific technical needs of the military. In the initial stage of the development of microelectronics the army was almost the exclusive recipient of scaled systems. In connection with the gigantic tempos of growth of the installation of electronic devices in military equipment, the number of active elements also grew. For example,

after World War II, the electronic apparatus in an airplane contained on the average 2000 elements, however, today it contains over 100,000 elements.

Usage and economic regard determine the requirements of the designers of military equipment for greater reliability, small dimensions, less weight and the economical feed of electronic equipment.

The first semiconductor scaled system authored by J. Kilby appeared in 1958. Initially the scale of integration of the scaled systems was not great. In subsequent years that scale grew, obtaining a present level of several thousand bits in one microwafer (semiconductor memory). In the group of scaled semiconductor systems, besides systems based on bipolar transistors, there appeared in the second half of the 1960's a new class of systems, the so-called MIS monolithic systems, built entirely of MIS transistors. Presently, scaled MIS systems make up the most dynamically developing direction of microelectronics. The direction of hybrid systems, especially in microwave applications and in complex functional blocks with a greater scale of integration, has been developed.

The small series production of hybrid systems with thin layer technology (a series of numerical systems or several types of linear ones) was developed in Poland in the second half of the 1960's. In 1972 in the Telpod factory was begun the large series production of hybrid thick layer systems. The large series production of semiconductor scaled systems with an assortment, which contained 10 types of numerical systems, was begun in August 1972 on the basis of a Soviet license.

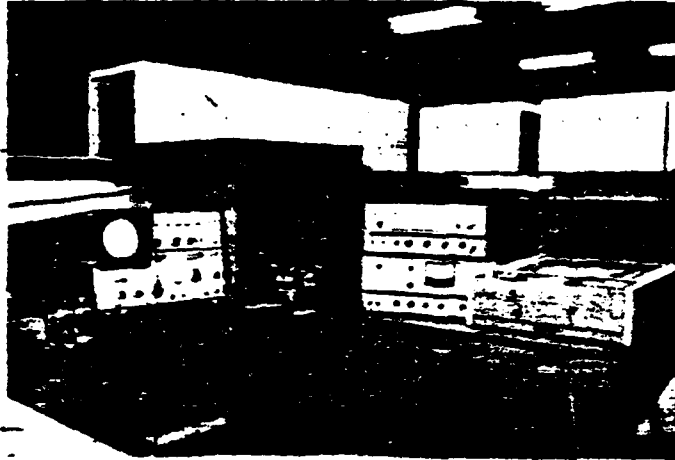
Scientific and scientific-didactic activities in the field of

microelectronics was undertaken in the WAT in 1968. The didactic laboratory also began research in the field of the electrophysical properties of semiconductor structures. In cooperation with the Tewa Semiconductor Factory several original methods were worked out for studying the electrophysical properties of MIS structures.

Scaled systems unquestionably comprised a transistional stage in the development of microelectronics, whose perspectives are seen in functional integration, that is in functional devices. In the near future microelectronics will be developed in the direction of the further improvement of the physico-technological methods for designing and producing scaled systems. The development of methods for the processing of information for continuous and discrete signals, that is the solving of problems of standardization and universality, which allows a broader introduction of large scale integration than hitherto possible.

A research station for the study of MIS structures

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MICROWAVE ACOUSTICS

Microwave acoustics is a field of science and technology which is occupied with the study of waves and acoustical systems, as well as their practical applications. Since the speed of acoustical waves is around 10^5 times less than that of electromagnetic waves, and the attenuation, which belongs to the length of waves of solid state bodies, is considerably less than in the case of electromagnetic waves, miniature systems with a determined constancy are possible. Acoustical-electrical, acoustical-clamping and acoustical-optical activities are important research tools in solid-state physics and are also used in practical applications.

Microwave acoustics find application mainly in equipment intended for the processing of radio signals. This is especially realized on delay lines and various types of filters intended for operation in radio communications, radio telephone and radar stations. For example, piezoelectric resonators are used for the stabilization of the carrier frequency. In modern radar stations delay lines are used in solid state systems and compression filters for the confinement of impulses, which considerably increases the discrimination range and the resistance of the station to disturbances.

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It can be admitted that the development of the applications of microwave acoustics was begun with the use by Cady in 1922 of a quartz resonator for the stabilization of the frequency of electrical oscillation generators. In 1936 a stability of around 5×10^{-8} was obtained using this method.

Today a stability on the order of 10^{-11} per month is obtained, which is comparable to the parameters of some types of atomic generators, with

a considerably simpler design.

In connection with the development of radar, already during World War II acoustical delay lines were used in radar intended for the observation of mobile objects. Quartz converters were used for the induction of acoustical waves, and mercury was used as the delay center.

The dynamic development of microwave acoustics was begun at the start of the 1960's in connection with the discovery of the method of the direct induction of surface acoustical waves in piezoelectric crystals. At this time work was also begun in the WAT, mainly on amplifiers and generators of acoustical waves in piezoelectric semiconductors.

In the mentioned field intensive theoretical research, experimentation and application was undertaken in the Military Technical Academy (WAT) parallel to foreign centers, and in some areas far outstripping them. Already in the last half of the 1960's Gen. Div. Prof. Dr. Hab. Engineer Sylwester Kalisky had developed and worked out in detail the theoretical fundamentals of an electronophonic amplifier, ideal resonators and self inducting oscillation generators. These developments dealt with the problems of the volume amplification of acoustical surface waves by electron currents, both in foliated piezoelectric-semiconductor systems and in monolithic piezosemiconductor crystals. Parallel to this, experimental work for the realization of theoretical conceptions was undertaken by a team under the direct supervision of Prof. S. Kalisky. The theoretical achievements and the experimental results obtained served as the basis for the awarding of the State Prize First Class to the team in 1970.

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Experimental work on electronophonic-clamping and optic-acoustical systems was begun on the basis of theoretical developments and designs.

The WAT is the leading center in this field in the country. These systems are now being introduced into industry. Production has been prepared to meet the needs of both defense and civilian industries, such as color televisions, computers, etc.

The present stage of development in the field of microwave acoustics is characterized by an intensification of basic research in the propagation and effects of acoustical waves in the anisotropic centers. This concerns both volume and surface waves.

Theoretical, experimental and applied work connected with acoustical-electronic, acoustical-clamping and acoustical-optical effects is also being intensively developed.

Microwave acoustics is now found in a stage of very intensive development. It can be assumed, therefore, that in the near future there will be a very rapid growth in the store of basic knowledge concerning acoustical waves and systems. The number of new materials, technological methods and practical applications of these systems in science and technology will also grow. This has become especially important and in the near future there will be developed such practical applications as: filters, delay lines on surface waves, filters for the correlated processing of radio signals in a real period, active delay lines, delay lines with a regulated period of retardation, electronically altered optical filters, modulators and light deflection systems.

Based on earlier discoveries it can also be assumed that there will be produced scaled acoustical, acoustical-electronic and acoustical-optical systems.

RADAR

Radar is a field of technology which encompasses the detection and determination of the location and the parameters of the movement of objects with the use of radio waves. With regard to the manner of obtaining information about objects--radar methods operate in the following ways: active with passive responses, active with active responses, semiactive and passive.

In modern radar systems all of the above mentioned methods are used together. Especially, information on the departure of a system is the result of the collaboration of equipment, operated by various methods. This has a tremendous significance because the existence of information parallel to the rule leads to an increase in the initial data's credibility. The military significance of radar is determined by its chief advantages. These are:

- the practical independence of operation from atmospheric and time conditions;
- its great range;
- the almost immediate obtaining of information about observed objects.

With regard to modern aerial objects this is a method of observation which allows the appropriate organization of defense. The significance of radar has not been diminished with the universal introduction of jamming equipment. The military necessity of jamming led, however, to the very considerable development of radar

stations and increased the range of radar systems (which contained a series of equipment operated by various methods and possessing various parameters), which can ensure the obtaining of reliable information, even under very poor conditions.

World War II was a period of the very dynamic development of radar. Today, we can talk about a certain "stabilization" in the field of the development of radar methods, although great progress has been observed in the field of new system developments, which can approach the theoretical limits of the possibilities of various methods. Modern radar stations can be developed only on a modern subsystem base and a developed scientific-research base, which allow a series of fundamental problems to be solved as rapidly as possible.

Radar in Poland as a scientific and technological field was developed in the 1950's. The introduction of radar equipment into the military was accompanied by the onset of domestic scientific and technical research. Domestic radar technology reached the level of the developed European nations. Frequently Polish equipment was exported and could effectively compete with the products of other countries.

Work in this field was carried on by the corresponding institutes of the WAT. Among others, an original research station was constructed for the study of detection, coordinate measurements and the differentiation of radar signals.

A system of instruments, realized by the analog method of statistical modelling made possible the accomplishment of a series of research projects connected with the numerical processing of radar signals.

The constant increase in the complexity of these devices comprises a new problem for their existing control. The versatile training of operators must take into account operation under conditions which most resemble real life. Therefore, various types of trainers and simulators, which increase the training's effectiveness, play a large role. Consequently, work on various types of target and aerial situational simulators was undertaken in the WAT.

The following developmental directions among others determine the development of further scientific research and the possibilities of the introduction of new technology:

- the automation of radar equipment and systems based on specialized and universal EMC;
- the optimization of detection and the measurement of the parameters of objects with the use of complex radar signals;
- the introduction of adaptable systems, which allow reception under jamming conditions;
- the combining of electronic systems with optical, acoustical and electrical ones.

Electronic technology, as well as its "combination" with optical, acoustical and electrical systems, has been developed very rapidly, making possible today the realization of concepts, which required up to now very complex and developed designs.

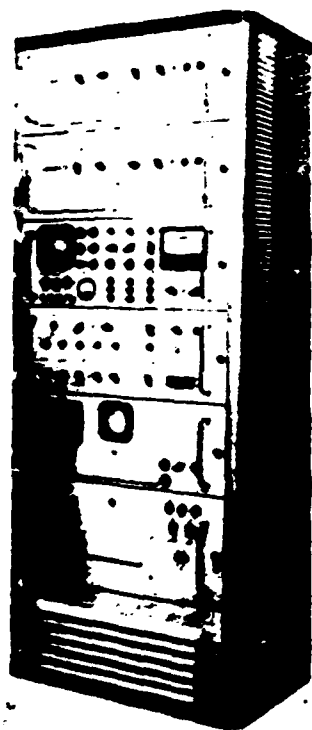
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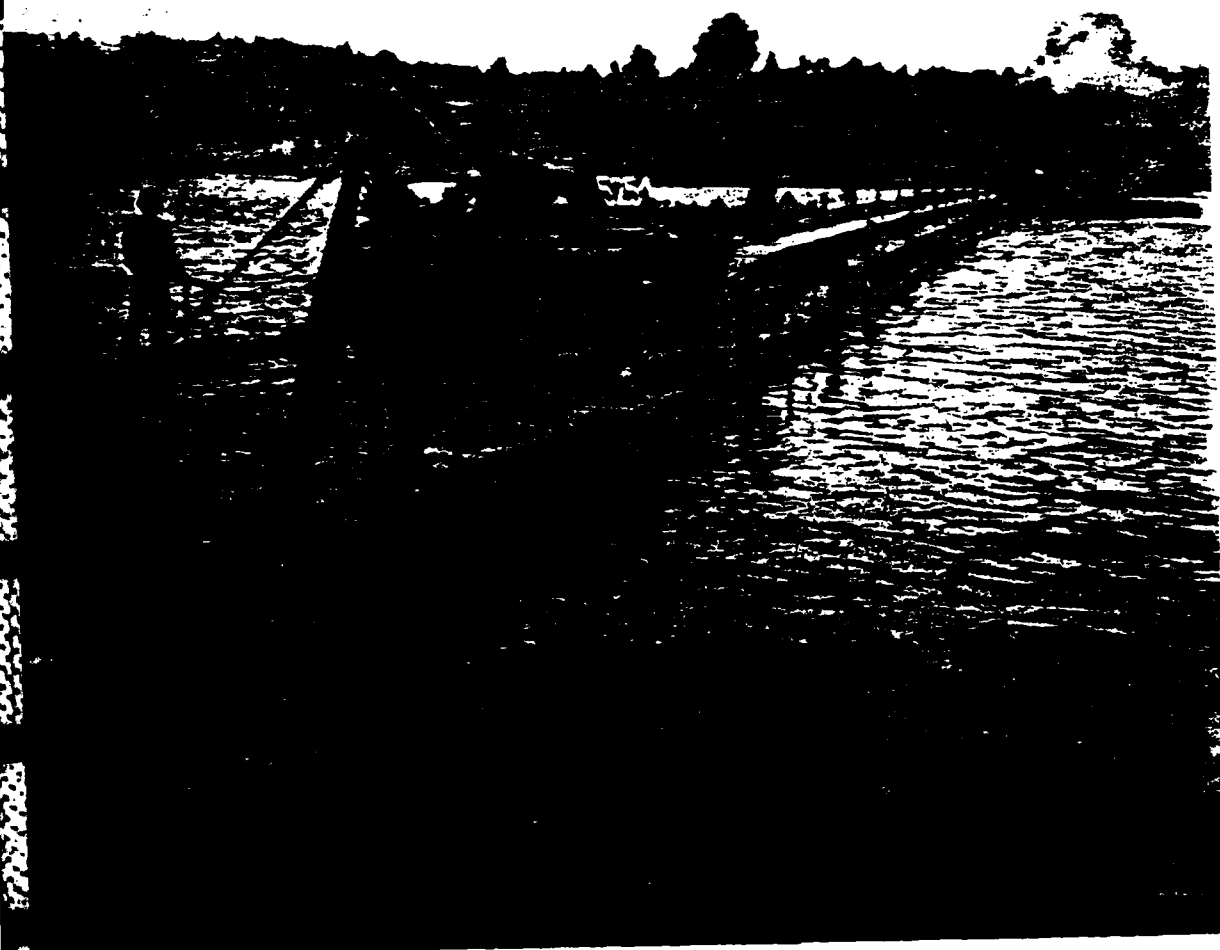
A unit for the processing of analog signals and their standardization



A command vehicle
at a battle station

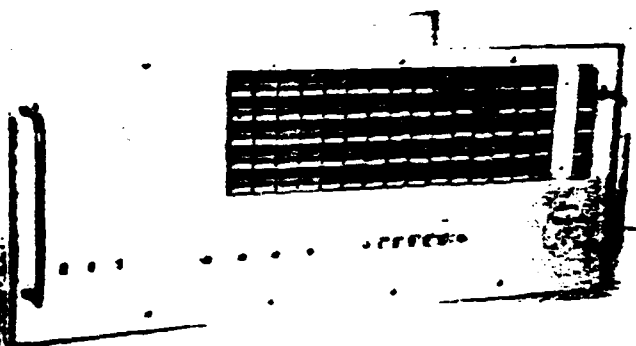


The source of radar signals,
which simulate the echo of
mobile targets and noise
disturbances

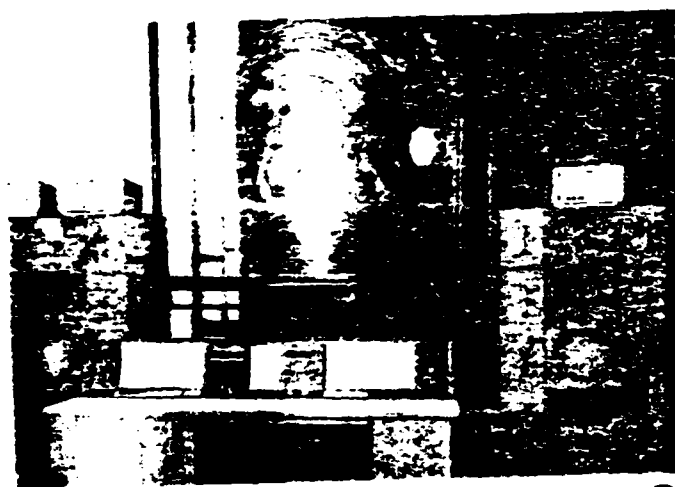


A tank on a
transit ferriage

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A statistical analyzer



A simulator of complex aerial
situations

TELECOMMUNICATIONS

Telecommunications is a field of technology occupied with the transfer of information over a distance by aid of electrical signals. By information we mean: sounds, moving pictures and photographs, texts, numerical data, physical processes and their measurement values. Information transfer can take place between people, between man and machines or between machines. The transmission of electrical signals over a distance can be performed over lines or radio.

The growth of the requirements inherent in military communications systems and equipment has stimulated both the development of corresponding scientific disciplines which deal with methods used in communications and that of technological fields which create the technical means for the construction of communications equipment and systems. Military communications technology, in many cases, has played the role of pioneer in the general development of communications technology and its achievements have been utilized in other ways to the advantage of society.

The importance for national defense of the overall state of communications which serve the national economy and guarantee its vitality and development has also grown considerably in recent decades. For this reason the development of modern military communications systems proceeds in close connection with civilian communications systems.

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The development of military communications in recent decades is characterized by the broad introduction of qualitatively new types of services. Besides telephone communications, already previously used on a mass scale, teleprinter communications have also appeared in

radio systems. The usefulness of telephone and telegraphic systems for military command purposes has increased thanks to the introduction of telecopying devices, which make possible the transmission of single frame pictures, for example graphic documents. In special cases moving pictures can be transmitted with the introduction of television. For users of automated command systems, data transmission equipment has been introduced which allows the transmission of information between computers or man and computers over line and radio channels with greater reliability.

Equipment and user connections were automated in order to increase the functional efficiency of communications systems. Thanks to this the rate of information circulation has grown. A considerable increase in the number of services has been achieved with the introduction of large capacity teletransmission equipment, especially multichannel telephone and telegraph devices and radio lines.

The elasticity and rational utilization of frequency ranges has been increased considerably in shortwave and ultrashortwave radio communications with the introduction of new types of emissions and the improvement of transmission and reception equipment. Resistance to atmospheric disturbances has also been increased.

The miniaturization of elements and subsystems make possible not only a decrease in equipment dimensions and weight, but also--and this has considerably greater importance--allows the development of equipment which often performs larger functions and is adapted to the realization of qualitatively new services.

Finally, scientific-research work connected with the development of military communications systems has been performed, above all, in the

Military Communications Institute and the Telecommunications Systems Institute (IST) of the WAT.

Scientific-research work in the field of data transmission, performed in the WAT's IST, has led to unique designs of machines for the transmission of data by radio. Their main application is to facilitate communication between computers or between man and computer. This is a key step in the creation of mobile information networks.

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The Military Communications Institute has several achievements to its name in the field of military equipment and the design of special devices for military communications. These deal with new directions in communications such as: line data transmission, alert systems, etc.

The basic direction of the further, perspective development of modern telecommunications is the total automation and integration of communications networks. Up to now the run system of automated centrals has dominated in the networks' commutation centers. Now the cruciform system of centrals has been widely introduced, which meets requirements in the field of the automation of national and international traffic. These systems, however, have reached the limit of their developmental possibilities and will not be able to meet the requirements of the future.

In this state of affairs research and development have been begun on the utilization of electronic technology for the formation of automated centrals. The introduction of electronic commutation equipment has allowed the tasks fulfilled by the telephone system to be expanded. The development of computers and progress made in the

technology of semiconductor scaled systems have created conditions favorable for the realization of new commutation concepts based on central programmed control, as well as the realization of new transmission concepts (a manifold increase with a decrease in time).

MEDICAL ELECTRONICS AND BIONICS

Medical electronics consist of electronic elements and systems, apparatuses, devices and methods, which are occupied with application in various medical fields (diagnosis, therapy, mechanical replacement of organs and their functioning, equipment for scientific research). Bionics, however, deals with the research, analysis and modelling of biological processes in order to utilize the obtained results for solving various technological and biological problems.

Medical electronics is not a new field. Its development is, however, dependent on progress in other technical fields: in electronics, precision mechanics and others. Therefore, the rapid development of technical sciences after World War II and the design of better and more modern elements, systems and equipment based on semiconductor technology have created very broad possibilities for medical electronics.

In Poland medical electronics are really a field of the future. Many research and design-production centers are occupied with this problem.

Medical electronics and bionics have a special application in the military. Besides utilization in military medicine, where the problems are similar to those in civilian medicine, specific issues

exist for the military. These include medicine on the battlefield, since equipment must be adapted to operation under field conditions, and consequently, among other things, must be shock resistant and consume the least amount of power possible in connection with supply needs from independent current sources, field aggregates of alternating current or other feed sources.

There is equipment for for military use which studyies the condition of soldiers: in the field, in the air and the water--and obviously transmits by remote control the physiological parameters of the sick personnel. Devices for the army have also been constructed which make possible the selection of individuals with the best physical properties for various military positions.

Medical electronics is a very broad field. Both current as well as perspective research is being performed in many directions. Below is presented some very important directions of its development.

The first field includes work connected with equipment which will register electrical signals generated by human organs. These include electrocardiographs (EKG), electroencephalographs (EEG) and electromiographs (EMG). These require very sensitive and stabile operating direct or free alternating current amplifiers. A method is being sought for obtaining the greatest amount of information possible (vectocardiographs, ballistocardiographs and in the future, magnetocardiographs). The miniaturization of systems is also a goal, so that these devices will have universal application.

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The second field is the complex gathering and analysis of the

different physiological parameters of humans, such as temperature, blood pressure, pulse.

Another field of endeavor in medical electronics is telebiometrics, that is to say the remote measurement of physiological parameters. On one hand an apparatus of this type allows the introduction of detectors inside the human organism (for example into the circulatory or alimentary systems) and the wireless transmission of information to analytical equipment; on the other hand it allows research on the state of people under various natural conditions: the runner in a race, the pilot while flying an airplane, humans in space, soldiers on the battlefield.

Radiology also has experienced progress. Hitherto, only x-ray equipment has allowed us to observe inside the organism for diagnostic purposes. Presently, new methods are being developed. Included in this is thermography, which registers via remote control change in the surface temperature of human beings and detects, among other things, phlogistic cells, tumors and sections of the circulatory system attacked by arteriosclorosis. Ultrasound holography has an even greater perspective, because it provides three dimensional pictures of the human body, and especially organs.

Prosthetics is and will be dynamically developed. This concerns the construction of mechanical prostheses with a large number of functions, controlled by electrical signals originating from the muscles, and in the future, from the nerves (as takes place in the organism). This concerns instruments which help the hard of hearing and deaf, as well as devices for the orientation of the blind, providing them with information about their surroundings. In the army, work in the field of medical electronics is being performed in the WAT and the Military Institute for Flight Medicine.

In the WAT, the Institute for Bionics and Medical Electronics is occupied with the problems of medical electronics. The institute was founded in 1970 in order to carry out didactic functions, train electronic engineers for the needs of military medicine and do research on the development and improvement of field medical equipment. In this instute there has been designed and constructed 280 models of field thermometers for the rapid, punctual measurement of the temperature of the human body--a processes taking less than 15 seconds. Work is being performed in the field of physiological optics, and in the field of acoustical holography experimental systems have been designed.

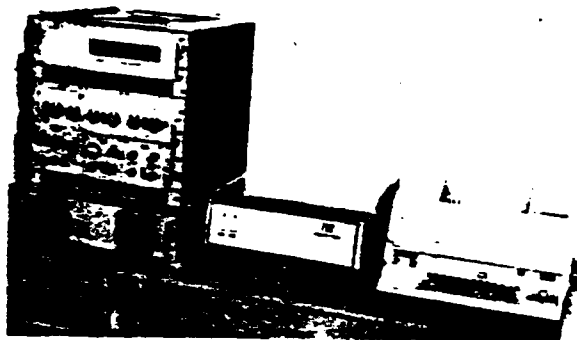
An entire series of measurement devices and equipment has been produced, which allows the observation of pilots (pulse, body temperature, etc.) both before and during flight.

A group examiner was constructed for the needs of aviation psychology. It allows the simultaneous study of the reactions of 14 pilots to visual (in the form of continuous light tests on their screens) and audio stimuli. Equipment has also been constructed for the testing of the dynamic acuity of vision, which allows the determination of a pilot's suitability for flight at low altitudes. Other instruments measures reaction time by studying the reaction rate to light impulses of both pilots and athletes (for example fencers).

The MRK 432 device for measuring alternating reaction time was designed as a result of the cooperation of the Central Pyschological Laboratory with CWKL and the Sileasian Center for Medical Technology. This device allows the measurement of reaction time to a series of light and sound impulses, the number of correct and erroneous reactions. Equipment for the total analysis of the state of individuals in complex situations (that is to say the simulation of

natural conditions) and devices for the automated analysis of test cards are also necessary for military psychology.

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Radio measurement equipment

9.3 RESERCH IN FIELD OF CYBERNETICS--SYSTEMS, THEIR EXPLOITATION AND RELIABILITY

With the contemporary level of science and technology there exists the possibility of the basic improvement of the organization and command of the army and of the direction of armaments. This can be created by cybernetics--the science concerning the general lawss governing the processes of control in machines and living organisms. Cybernetics, as a general theory of the processes of control, encompass many disciplines concerned with the processes of control, and among them with the theory of control of large systems, operational studies and computers. These fields make possible the complex automation of command for the military and battle centers, and the realization of command and management processes.

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The technical means available to modern cybernetics include the most complex equipment ever created by man. It will be even more difficult to surmount the barrier of complexity in the future. Therefore, the knowledge of the appropriate usage and servicing of these complex devices and the problem of their reliability has become a terribly important matter. The fields of science, which deal with these problems are: the theory of the exploitation of these machines and the theory of reliability.

THE THEORY OF THE CONTROL OF LARGE SYSTEMS

Every complex system with interconnected elements, which is organized for the realization of a determined goal and operates in an active environment, is characterized by the fact that it contains a control system.

The task of control is to accurately influence the system's working processes so that its operation can proceed smoothly and that disturbances arising from the environment can be counteracted.

The essential trait of control is the flow of information. The flow of information, in a general way of speaking, is organized in accordance with the principle of reverse connection. Reverse connection is a principle which holds true for all systems, which actively counteracts the negative effects of the environment and changes in the constituent elements. The essence of the principle of reverse connection rests in that in a system, in which it operates, its functioning depends on information concerning the degree to which its task has been accomplished. If this information (for example the distance from the established target) affects the operation in such a way that the system approaches the target, we can speak of a negative reverse connection.

The science occupied with the study of the process of control, with methods of analysis and synthesis of necessary control is called the theory of control. The theory of control and the automation of control have been the subject of intensive study and practical application in the last 30 years. The main stimulus for the development of the theory of control and the automation of control was and is military technology and its directing by complex systems. Such equipment as radar with automatic target tracking, autopilot, guided missiles, tank turret stabilization, aerial, naval and land navigation, and robots require complex systems of automated control. In modern military systems: in air defenses, aircraft and land armies, requirements from the field of control have grown considerably. 282

In the above systems are engaged greater power and resources.

Therefore, the coordination of the operations of individual elements of the systems and the precision of the processes of characteristic magnitudes in the system influences in an essential way the operation's results. It can be considered that control is one of the main sources for increasing the efficiency of systems' operations.

These problems affect the direction of scientific research in the field of so-called large systems and in the technology of automated control.

The size of the systems in military technology is characterized by its multidimensioned quality. And so, in the control of rockets, airplanes, tank turrets there appear two or three regular sizes. Therefore, the essential problem is the analysis of the stability and quality of the multidimensional systems of automated control. The WAT has performed a series of studies on this theme.

An important part of the theory of control, which has begun to be developed in world scientific centers in the 1960's, is the theory of systems adaptation. Adaption capability, often with the automated modification of their parameters, is a positive characteristic of control systems used in military technology.

A series of interesting work in the field of systems adaptation has been performed in military agencies. Work has been carried out, for example, on the theme of the adaptation of a system which tracks the properties of exiting signals. The purpose of the adaptation was to obtain the smallest possible tracking error of airborne targets.

In other activity from the field of systems adaptation the properties

of adaption control have been reanalyzed. The prediction of an object's behavior plays a key role.

Work on the theme of learner systems also must be included in the category of cognitive research in the field of the theory of adaption control. The essential trait of these systems is their ability to learn to recognize a new situation and to initiate the proper action. One of the theoretical designs in the field of learner systems was presented in the IFAC congress in Basel.

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For practical applications, and especially military ones, so-called differential games are an important part of the theory of optimum control. Problems of guiding aircraft and rockets, the problem of an aircraft's escape from jet fighters, pursuit and the escape of naval vessels are resolved in differential game modelling. In the Military Technical Academy a series of basic and applied research has been and is being performed in this field.

One of the most important problems of the theory of control for military application is the theory of large systems and the automation of control systems. In this case, not just individual instruments, but a complex system of humans and machines distributed in many areas are considered. Individual elements operate here partially automatically, but realize a common, organic goal. The problem of control of such complexes, the matter of the automation of the control of individual elements, the mathematical and technical sources and the programming for the realization of an automated system of control are presently the subject of intensive research and modelling designs. Implied for the development of the above theme are such needs for military systems as: national air defense, an aircraft control system, a system for the direction of anti-aircraft defenses, a system for the direction of the operations of land forces, and

generally--a command system at the various ranks and in the various branches of the armed forces.

As a subject of research the theory of large systems is a collection of interconnected elements-subsystems, which carry out a common goal. Every subsystem has a defined purpose of activity. Accomplishing this, it affects the realization of the general goal. The connections between the subsystems have a material-energetic or informational character.

An essential problem of the theory of large systems is the testing of the effect of the state of the elements on that of the system.

A basic principle of the systems approach is the division of the overall problem into a series of interconnected subproblems. Various structures, most frequently hierarchical ones, are created in this way. The theory of large systems is the basic theoretical organization and automation of control systems.

In military scientific-research agencies, and especially in the ITWL and WAT work in the above field is being carried out on a broad scale. Cognitive work concerns mainly the description of a mathematical system, the algorithmization of decision making, structures, the principles of control and the study of the system's efficiency.

In the realm of application basic achievements of the military agencies must be noted in the automation of the command system of the air defense forces. The development of machinery, soft-ware, systems projects, algorithms for the realization of frequent tasks, makes up the key achievements in the last decade.

From the earlier recognition of the needs and perspectives of development and research in the field of the theory and technology of control it follows that the greatest efforts are being made in the field of large systems, in the area of the methods of designing automated control systems and in the technical means of informatics. Increasingly more complex objects and processes require automated control systems. It has been noted that the human environment has become all the more frequently the object for which control has been anticipated and in which the automation of some control processes has been introduced. The problems of controlling the development of the environment, the management of the Earth's resources, the establishment of programs for the development and organization of activities performed for the realization of these programs, have become essential for humanity.

OPERATIONS STUDIES

Taken generally, the historical appellation, "operations (or operational) studies," does not define precisely this field of knowledge. It would be more appropriate to call it: the science of activities. Taken most generally, the field of operations studies is the problem of the analysis (study) and synthesis (organization) of human activity, from the point of view of the widely understood efficiency of activity. The basic method is to construct a model of the mathematically studied phenomena and to determine the mathematical algorithms of the problems' solutions.

With regard to the problem, the most akin sciences of operations studies are: praxeology, economics and operational tactics and arts, although with regard to the method--mathematics and physics.

In its development, operations studies have created a series of their own mathematical methods (for example mathematical programs), which have subsequently found a permanent place in the general wealth of mathematics and have lead to the formalization of the description of a series of problems (for example games theory) and their efficient solution. 285

The appellation, "operations studies," appeared in around 1939 and initially concerned exclusively military problems. We can consider Lancaster (the mathematical model of war) and the Polish mathematician, Steinhaus (the mathematical model of games) as precursors of operations studies in the military field, and Erlang (the model of the service process) and Kantorowicz (the mathematical model of production planning) in the field of economics.

Domestic development of operations studies, although one sided, proceeded during the World War II, in a period in which the need for new methods of waging war with the increasing tempo of the introduction of new, battlefield technology had rapidly grown.

Only after World War II, in the 1950's, was operations studies developed for application in industry and the management of the economy. And so, econometrics arose. In the field of planning on the enterprise level the PERT methods and mathematical programming were developed, in the field of management--the analysis of goals, in the field of techonolgy and the economics of production--the analysis of value, in the field of systems design--systemotechnology and the analysis of systems, etc.

The first center in Poland, which was occupied with operations studies, was the Military Technical Academy and the Academy of the

General Staff.

The greatest efforts of the scientists working in the field of military operations studies were simultaneously concentrated on the construction of models of complex military operations, which used their course and operational planning for prognosis. In the civilian field the greatest progress of operations studies was observed in the problems of production planning, the optimizing of supply and transport and complex management and the supply of information. The tremendous progress in technology, which we have recently seen especially in the field of computers, has contributed to the present progress in operations studies.

COMPUTERS

Computers are machines intended for the automated processing of data in the broad sense of that term. Numbers are only one of the types of data and with their processing we have to deal with the performance of numerical calculations by a machine. However, the possibilities of computers are considerably broader and numerical calculations only make up a percentage of the total possibilities of their application.

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All of the activities connected with the production, programming and utilization of computers are now called in Poland, as in most of the states of Europe, information science. Information science is a very young field. The first modern computer was developed at the close of World War II for military needs, and although this certainly was not foreseen, today it has penetrated into almost every field of human activity. In the military computers are used for both command purposes and in order to meet material-technical needs. They are also used in military research institutes for improving armaments and in units for training purposes.

With regard to the principle of their operation, computers are divided into digital computers--with discrete operation, and analog computers with continuous operation. On the edges of these two divisions are hybrid computers, which, besides an analog part, possess a more or less developed digital part--mainly in order to control the course of data processing.

Analog machines, as well as hybrids, do not have as universal an application as do digital machines. They are most often used for the modelling of continuous phenomena, for the solving of some complicated mathematical problems--for example systems of

differential, partial and other equations. The share of digital machines in the general profile of both civilian and military applications is uncomparably larger.

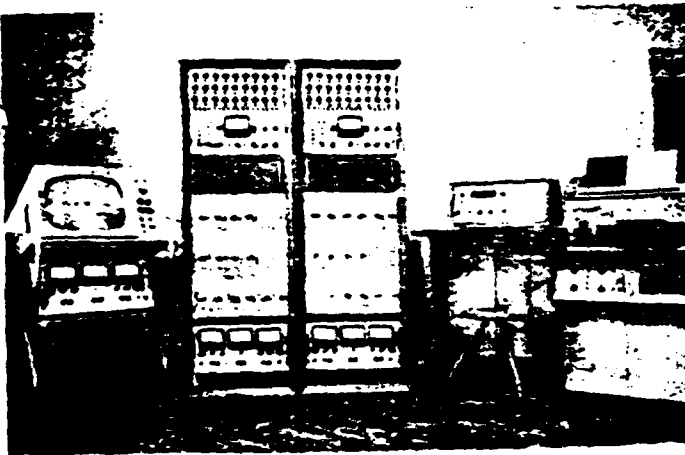
The first Polish universal digital computer was the XYZ device built and operated in the then Institute for Mathematical Apparatuses of the Polish Academy of Sciences (PAN) in 1958. The first work on computers in the WAT was begun at this same time. In 1960 the BINUZ universal digital computer and the UMA-60 universal analog machine were introduced here. In 1963 the JAGA-63 digital analyzer--a special digital computer-- was constructed in the WAT. In subsequent years tens of analog computers were built in the WAT. One of these, the ELWAT, was produced in Wroclaw between 1965 and 1969.

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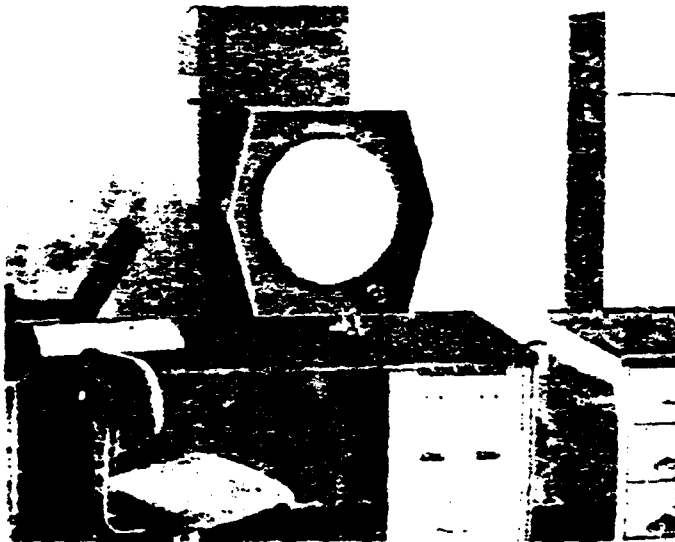
Presently, individual models of larger hybrid machines, the WAT-1001 and WAT-1010 are being built in the WAT. In the field of digital computers, work has recently been begun on specialized input-output equipment, which facilitates the processing of graphic data. From this series there has appeared: a digital integrator for the measurement of the fields and factors of plane figures, and a digital graph duplicator for the exchange of graphic information in a digital form, which is transmitted for direct input into the machine or graphical display, which is the first device in Poland intended for the bidirectional communication of man and computer. Such machines are necessary for many contemporary applications in the automation of military command processes.

A series of technical-program work connected with the utilization of digital computers for the needs of national defense has been recently undertaken in the Air Force Institute.

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The ELWAT analog computer, designed in the WAT and produced in by the WZE ELWRO between 1965 and 1969



The first Polish graphoscope--which collaborates with the Odra-1204 computer, introduced in the WAT in 1970



A data register for recording on standard magnetic tape

THE THEORY OF THE EXPLOITATION OF MACHINES

The theory of the exploitation of machines (technical exploitation) is the science of the processes of utilization, the processes of servicing and of the systems, in which these processes are realized. The object of exploitation can be individual machines or groups of them.

This requires that every machine have the optimum durability, maximum reliability and maximum efficiency. The science of the exploitation of machines deals with the collaboration of man and machine, from the moment of the machine's production to its destruction, in a state of use or renewal (servicing). In connection with this the science of the exploitation of machines includes the following three fields of research:

- the theory of the durability of machines (included in this is tribology);
- the theory of the reliability of machines and complex technical systems;
- the theory of the systems of machine exploitation.

The significance of the development of the theory of exploitation for the military rests in that this field of knowledge is creating the theoretical basis for the practical working out of the probability exploitation characteristics of motor vehicles, armaments and military equipment (technical equipment), for tactical and operational connections, which allow the command to optimally program the efficiency of its forces' effect on the enemy. The theory of the exploitation of machines provides engineers, employed in military technical services, with practical methods for the optimum use of military equipment.

The center, which has initiated the development of the theory of the exploitation of machines in Poland, is the Military Technical Academy and the Unit for the Theory of the Exploitation, founded in the WAT in 1960. This unit has gathered tens of specialists both from military and civilian centers.

Work performed by military institutes, and above all, the Air Force Technical Institute and the Military Institute for Armored and Motor Vehicle Technology, also has great significance for scientific research concerning exploitation characteristics. A series of studies on the physics of exploitation and the optimizing of exploitation systems was developed in these institutions.

The results of the work performed in the military scientific agencies were introduced into the military and national economy, for example: new techniques for the conservation and maintenance of military equipment, new methods for non-destructive testing, methods for the accelerated running of combustion engines, new friction and lubricating materials, mathematical models of reserves, preparedness and others.

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Many of these labors were published by the Wydawnictwo Naukowo-Techniczne [the Scientific-Technical Publishing House], the Panstwowe Wydawnictwo Naukowe [the State Scientific Publishing House] and in materials from conferences and symposia. There are also numerous publications found in the scientific and technical journals and in the scientific volumes of the work of individual agencies, for example the Prace Zespolu Teorii Eksploatacji WAT, the Informator WITpiS, etc.

In the MON Publishing House the Military Engineering Library was

initiated. An exploitation series (7 volumes are now ready to be printed) has been developed in it.

Besides scientific activity, military scientists have become very active on the organizational level. On the initiative of the scientists of the WAT, ITWL and WITPiS, the Section for the Exploitation of Machines of the PAN has been created. It is connected by close cooperation with engineering associations and enlivens their scientific-technical activities.

Broad collaboration is connected especially with the Section for the Exploitation of Technical Machines and Devices of the SIMP and the Commission for Exploitation of the SEP. Also, thanks to the efforts of military circles, the publication of the scientific quarterly, Zagadnienia Eksploatacji Maszyn, by the Polish Academy of Sciences, and the technical-economic monthly, Eksploatacja Maszyn, by the Main Technical Organization, has been begun.

Judging from the directions of the development of scientific research in the fields of tribology, the theory of reliability and the theory of the exploitation of technical machines, it must be admitted that the science of the exploitation of machines has been developed at an exceptionally rapid rate in recent years.

It should be stated that the practical results, which in the near future will be achieved in this field, are:

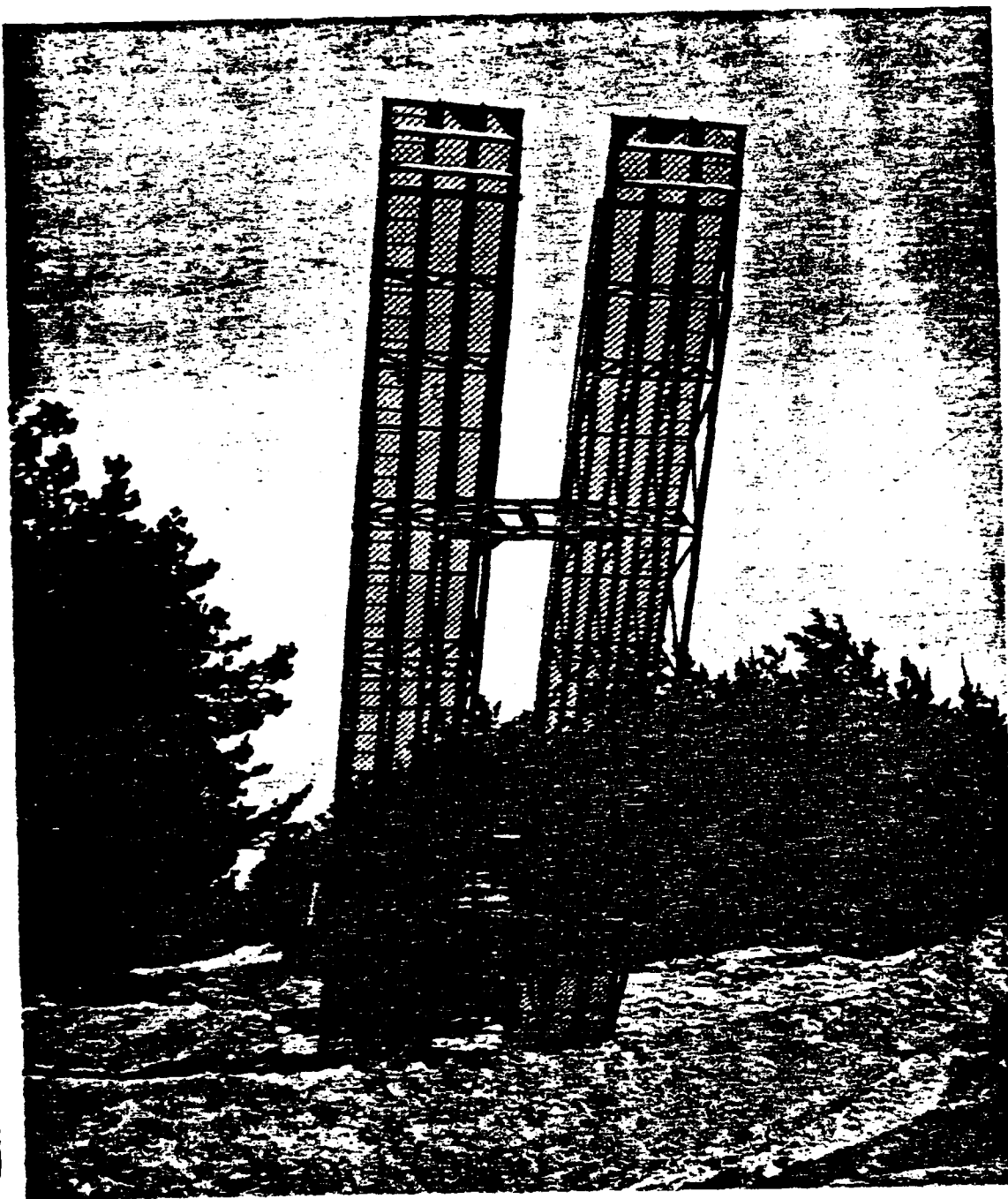
- the basic durability characteristics of technical equipment used in the national economy (transport, communications, production and military equipment);
- the basic reliability characteristics of technical equipment used in the national economy;

--the algorithms and optimum principles of the organization and direction of systems of the exploitation of basic technical equipment;
--modern training programs for exploitation cadres of various levels;
--modern research methods for the exploitation of technical equipment.

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The disinfecting of weapons



A concurrent bridge

THE THEORY OF RELIABILITY

The theory of reliability is a scientific discipline which studies the general laws, which must be considered when designing, producing and utilizing machines (objects), in order to use these machines with maximum efficiency. The term, "object" is used in the broad sense and can include elements, machines and even a system of human operators. With regard to the necessity of considering those factors which influence the object's condition, many disciplines are widely used in the theory of reliability. These include: the calculation of probability, the theory of stochastic processes, mathematical statistics, methods for statistical optimizing and modelling on a computer. Presently, the so-called broad concept of the reliability of objects is being used. This definition encompasses, among other things, such properties as: the object's resistance to damage, its durability and malleability. Depending on the object's designation, the above properties are determined by various types of reliability indicators, such as: the expected time between repairs, the expected time for the the localization of the damaged element, the expected repair time, the probability of proper operation, function or the readiness factor.

The conditions necessary for the exploitation of military equipment are considerably more fluid than those for equipment used in the civilian economy. Also, the state of the equipment is decisive for the level of the fighting unit's preparedness, and therefore, has a basic significance for national defense. Hence, military equipment must be characterized by great reliability. The attainment of great reliability requires on one hand the realistic evaluation of the existing equipment, and on the other, the consideration of the factors of reliability at the design and production stage of new types of weapons. This requires the continuous designing of new, adequate testing methods for reliability problems, as well as methods for

designing equipment with the required reliability values.

The problem of the reliability of machines is very old. However, only the dynamic development of technology and industry has given this problem an essential significance. In the Soviet Union theoretical work on the problem of reliability was undertaken even before 1950, but experimental and technical work was begun on a large scale in 1958 at the behest of the NTORiE organization (The Scientific-Technical Organization of Radio Technology and Electronics). The rapid development of this discipline in the USSR, intensified subsequently by the space program, the development of defense and the automation of industry, dates from this time.

Work in Poland on the reliability of electronic equipment began on a broad scale between 1955 and 1957 in the Warsaw Polytechnical University and the Industrial Institute of Telecommunications. Military institutes, and especially the WAT and the Center for the Testing of Communications Equipment in Zegrz, played a major role in this problem.

At the end of the 1960's the Polish school of the theory of reliability influenced to a significant degree the direction of scientific research in this field throughout the world and played an active role within the framework of the CMEA in the working out of the norms and terminology having to do with the application of the theory of reliability in industry and the economy. Within the framework of this direction work connected to the design of radio electronic equipment for armament needs was developed in military scientific agencies, and especially in the WAT.

The multi-year activity in the field of the reliability of complex

exploited objects has yielded results in the form of a series of theoretical and practical achievements, such as:

- methods for optimizing the process of the technical servicing of complex objects;
- methods for raising the indicators of the exploitation reliability of radar stations;
- the working out of the algorithms and programs for digital computers allowing the diagnostic procedures of technical objects to be optimized;
- the testing and analysis of the reliability of such radio electronic devices as televisions and radar;
- the designing, testing and introduction into production and exploitation in the military of automated diagnostic equipment for the control of the production and design conditions of radar stations, which lead to a significant increase in their technical preparedness.

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The modern issue of the theory of reliability proceeds from the reliability of elements in the purely statistical sense to the studying of the external and internal effects of physical factors on the indicators of reliability. It also encompasses the so-called accelerated testing of the reliability of objects under difficult conditions. The next point of interest is today the problem of evaluating the reliability of complex systems; the old concept of "the damaged object" is no longer adequate. It is now necessary to use a much subtler evaluation of the efficiency of a system's operation in its various possible states. Another problem is the working out of a method for the designing of such structures of technical equipment, which would be characterized by correspondingly great reliability or would make up a compromise between the cost of production and the need for reliability (the problem of the optimum indicators of reliability). Moreover, practice demands from the theory of reliability the working out of improved statistical evaluations of reliability and methods for anticipating damage, based on abridged studies with small statistical samples. Work concerning the

optimizing of the processes of the exploitation of technical equipment is presently being widely developed. This concerns the problems of determining the life and prophylactic capacities normal for reserve parts, the optimum methods for controlling their condition and the localization of damage.

9.4 RESEARCH IN THE FIELD OF MECHANICS

The mechanics of continuous media is a science, which provides the general basis for the development of thermodynamics, the theory of electromagnetism, hydrodynamics, the dynamics of gases, the static and dynamic theory of efficiency, thermal efficiency, plasticity, viscoplasticity and thermoplasticity, the theory of creep, fatigue, the theory of detonation and several other fields of physics. The common bond linking the above mentioned, apparently dissimilar disciplines of physics is the reason for considering them as a whole. The role of the mechanics of continuous media in the development of modern military technology is substantial. The following are some problems solved within the framework of this branch of science:

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- the drilling of tunnels, shafts, subterranean passages, canals, the destruction of rock strata by aid of explosive materials;
- the diffraction of pressure waves generated by nuclear or classical explosions on fortified objects built on loess soil and in water;
- the collision of ciagly osrodkows at great speeds and the penetration of projectiles and accumulative flows into solid bodies;
- the dynamic durability of the percussively functioning elements of various machines (motor vehicles, flying devices, shells);
- the programmed fragmentation of shells;
- the stamping, plating, the pressing of powders, the surface consolidation and welding of metallic elements by explosive methods (multilayered armor, special cisterns, the covering of flying devices, etc.);
- the analysis of the stresses and deformations in the elements of various machines and objects;
- the fatigue and cracking of materials under conditions of static and dynamic load.

In this chapter we will discuss in short the main achievements of the mechanics of continuous media and will show the perspectives for its

development in the Polish Army in the following fields:

- the propagation of stress waves (plastic, concussion and detonation) in inelastic media and their effect on non-stationary objects;
- numerical methods for the solving of the problems of initial-boundary equations of mathematical physics;
- the analysis of stresses and deformations;
- the study of machine systems and elements.

THE PROPAGATION OF STRESS WAVES IN OSRODEK NIESPREZYSTYCH AND THEIR EFFECT ON NON-STATIONARY OBJECTS

The study of the propagation of stress waves with amplitudes exceeding the limits of a material's plasticity, begun by Donnel in 1930, was totally ignored until the 1940's, when the concrete needs of military technology forced scientists to study this field intensively.

From the end of World War II ensued the rapid development of this scientific discipline. The appearance of nuclear weapons and new fortification issues connected with this were factors for the acceleration of this type of research. The development of supersonic aircraft and space rockets (the short-term intensive thermal and mechanical percussive charge, which generates stress waves, propagated in the structural elements of the flying apparatus) also stimulated this research.

Two centers in Poland, the WAT and IPPT-PAN, are occupied with the propagation and diffraction of stress waves in inelastic bodies. We will discuss in short the main achievements of the mentioned centers in the field of wave dynamics.

Based on a simplified elastic-plastic model--the Prandtl model with an elastic and rigid relaxation, which well approximates among other things the physical-mechanical properties of dry sandy soils, one can obtain a series of closed solutions for the complex problems of the propagation, reflection and effect on structures built on soil of the nonlinear stress waves, generated, for example, by the surface shock waves of a nuclear explosion, of the flight of supersonic aircraft or even by the explosion of a conventional charge of explosive material.

Research has been broadly developed on the propagation of elastic-plastic and elastic-viscoplastic waves of stress in physically heterogeneous bodies, which are classically represented as soil. A series of approximate and closed solutions are obtained here, which lend themselves to practical application, for example in the construction of fortified objects and geological studies.

The effective closed solution of the problem of the resonance of plane stress waves with strong discontinuity of both common and percussive types in elastic-plastic and elastic-viscoplastic bodies was published for the first time. This determined in an analytical way the cycle limits to which the amplitude of the nonlinear longitudinal vibrations of the elastic-plastic and elastic-viscoplastic limiting rods tended.

The solved problem has an essential practical importance, beyond its scientific values, in the field of the dynamic reliability of plastic materials.

The problems of the propagation of thermal stress waves in the above mentioned plastic bodies were also studied.

One of the present problems of modern continuous media dynamics is that of diffusion, mutual influence and diffraction in two and three dimensional obstacles to stress waves in inelastic bodies. This is a new field of research and little is written on it. In the WAT a local method of solving the spatial initial-boundary problems of continuous media dynamics has been worked out, based on the Taylor series. Several practical problems have been solved by aid of this method. Namely, the determined local pressure field (in the area of the reflection) in barotropic liquid arises with the reflection of a spherical concussion wave from a rigid barrier (for example the effect of an explosion of a mine on the hull of a ship or submarine). An analogous problem has been noted for viscous and elastic-viscoplastic bodies. One must stress the fact that this is the first effective solution of this important practical and at the same time very difficult problem to be published. By aid of this method the reaction, among others, of an asphalt layer to an abruptly moving charge, which travels around its surface at super- and subseismic rates can be determined. The great effects which dampen this layer can be analytically shown. It can be used to amortize the dynamic proclivities of fortified objects. Moreover, with aid of the discussed method, the creation of the waved surface of a bimetal junction, produced by an explosive method, can be analytically documented.

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Broad based theoretical and experimental research has been carried out on the programmed fragmentation of shells. Promising results in this field have been obtained.

It should be stressed that the very complex and complicated problems of the effects of pressure waves on subterranean objects have lead to useful forms suited for practical engineering calculations. A complete system of manuals with corresponding calculation tables and programs has been worked out in this field for designers. The cited

work has eliminated the need for the costly commissioning of foreign centers to solve this type of problem.

One of the fields which utilizes the energy of concussion waves is high speed metal technology. Included in this concept are the stamping, plating, pulverization, surface solidification and welding of metallic elements by explosive methods. Sources for concussion waves are high explosive materials, explosive mixtures, powders, rocket fuels and electrical charges.

Three Polish centers are occupied with the above mentioned problems: the WAT, IMP and Gdansk Polytechnical University. Presently, the most advanced work on the utilization of explosive materials in metals technology is being conducted by the WAT.

A great deal of experimental and theoretical information has been obtained in the field of the bonding of metals using explosive methods in order to obtain bimetals with a broad range of applications in the following industries: chemicals, petrochemicals, ship building, motors, tools, electronics and many others. An appropriate metals bonding method has been worked out and the critical parameters, which condition the creation of a positive weld, have been established.

The technology of the explosive expanding of pipes in the bottoms of different types of heat exchangers has been mastered and produced. In a few cases the explosive stamping of various construction elements was used.

We will now take up a short review of the perspectives of the development of the wave dynamics of solid bodies. The majority of the

above mentioned solutions were designed on the basis of the theory of minute deformations, which significantly limits the applicability of the results obtained in practice. In the future it will be necessary to endeavor to obtain analogous solutions for problems within the framework of the theory of finite deformations, taking into consideration the effects of heat conduction. There is a lack of effective solutions to the problems of the propagation of unidimensional concussion stress waves in heterogeneous physical bodies. This is similar with multi-element bodies described by the model of high speed bodies (hydrated soils). The specific, unrecorded separation of wave dynamics makes up the problem of the propagation of concussion waves with regard to phase transformations and ionization of bodies on the strong fronts of discontinuity. Other problems consist of the propagation of hyperintensive unidimensional concussion waves in connective electro-magneto-thermo-mechanical fields with a very wide range of practical applications, especially in the field of high pressure physics and controlled thermonuclear reactions. Noteworthy from an applied and scientific point of view is the hitherto open problem of the propagation of surface stress Rayleigh waves in plastic bodies.

In the field of the utilization of the energy of explosive materials science should aspire to mastering the technology of new explosive materials with a broad range of value--detonation rate variations. In accord with world tendencies research on the penetrability of accumulation currents must be intensified. We have in mind here new methods of the accumulation of detonation waves.

THE USE OF NUMERICAL METHODS IN MECHANICS

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Computers have lead to a real revolution in the field of the solving of problems in continuous media mechanics. This concerns not only the

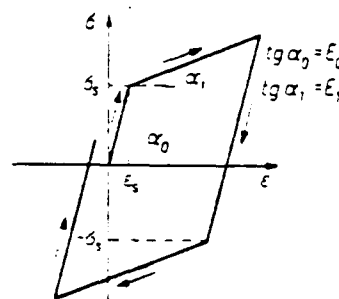
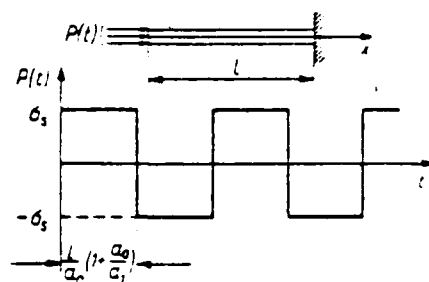
possibility of obtaining solutions for problems, which earlier were considered as insoluble, but also the means by which the solutions are obtained. This deals with modern numerical methods, as well as with concepts concerning the formulation of these problems. By solving problems we most frequently mean not complicated mathematical relations, but ready, working programs on computers, which upon the introduction of the necessary amount of data, calculate and print the results or plot graphs from it. The methods used to obtain these results are often quite different from their traditional forms and are characterized by originality and inventiveness. These are different variants of finite differential methods and the methods of finite elements.

These modern tendencies also have found application in the military.

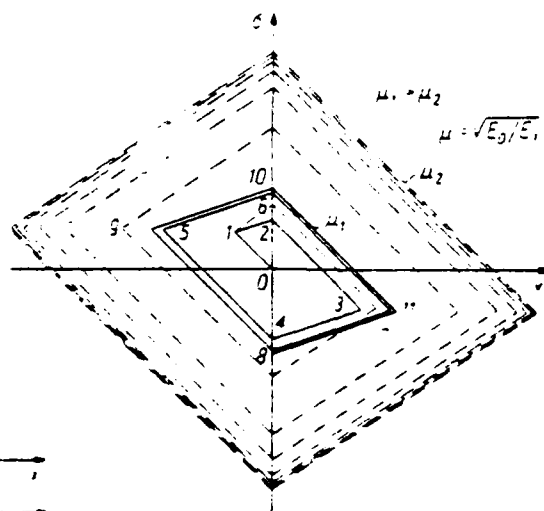
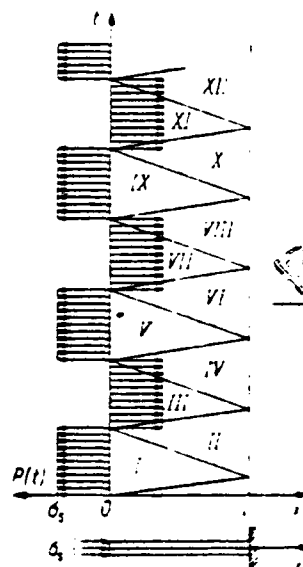
In the WAT computer software has been completed and equipped with proficiently operating translation languages (SAW, SAS, WAT-1), which has allowed the solving of a series of questions, from the dynamics of deformed bodies and aero-elasticity. The working out of the ASTER algorithmic language has significantly rationalized programming. As a result of this, production has been started of a series of programs which serve in the calculation of the dynamics of soils (wave processes) and the dynamics of fortified objects, subjected to the effects of concussion waves. The complete set of tens of different programs has allowed the performance of manifold calculations and the analysis of the above mentioned problems. In the course of the working out of these programs a method for the calculation of wave processes in layered bodies, which utilizes the properties of computer technology, has appeared, which is different from ones hitherto used.

Work has been begun on the use of the method of finite elements for the

calculation of design durability of complex forms. This work was and is being continued with the use of a new generation of computers. As a result of this a series of programs, which allow durability calculations for many structures with basic practical significance and can graphically present their results, has been obtained. This work has been meet with universal interest, and with the aid of produced programs, calculations in many national centers have been performed for various needs (sewage lines, production in mines, turbine blades in airplane engines, etc.) 300



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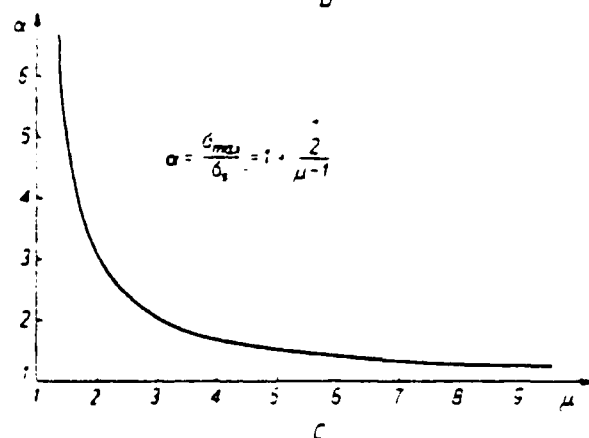


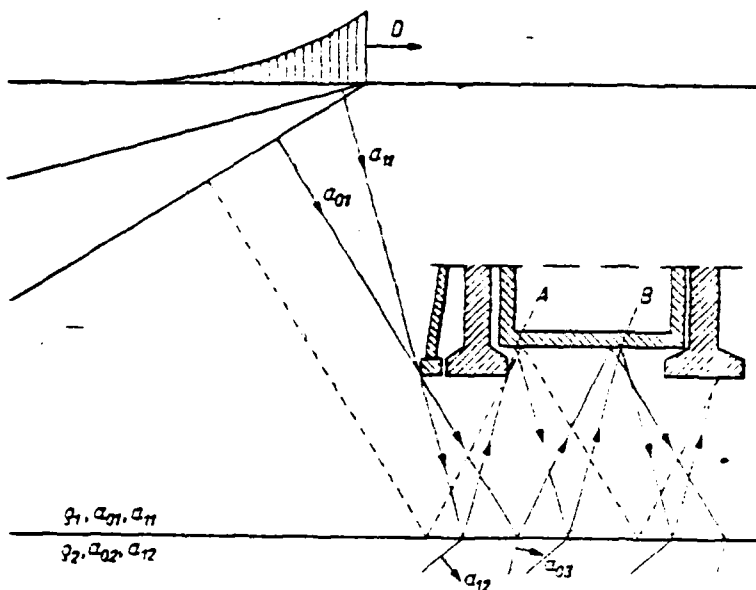
The resonance of elastic-plastic waves;

a--the load of the end of the pret and the characteristic σ - ϵ ;

b--the plane phase x , t and the boundary cycle in system σ - v ;

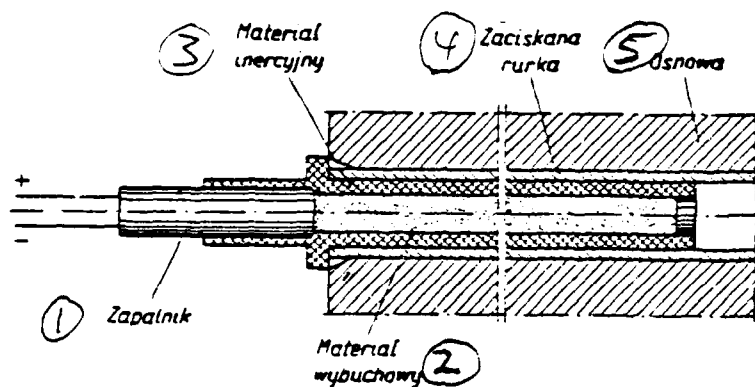
c--the graph of the coefficient of amplification α as a function of μ





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The effect of the concussion wave of a nuclear explosion on an object built on soil



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The explosive expanding of pipes in the bottom of heat exchangers--a profile of the charge

1. detonator, 2. explosive material, 3. inertial material, 4. compressed tube, 5. frame

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THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY 30
YEARS OF DEVELOPMENT(U) FOREIGN TECHNOLOGY DIV
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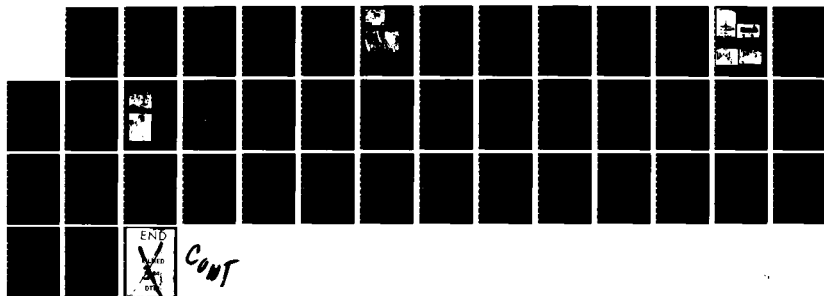
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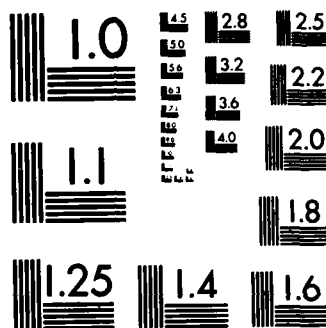
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AN ANALYSIS OF STRESS AND DEFORMATION

An analysis of stress and deformation is the basis of the rational designing and exploitation of all types of military technical structures. The goal of this type of research is to define the dependence between loads and the state of dislocation, deformation and stress of structures caused by them. The cited states determine the carrying capacity and usage life of the object. Research has been performed using both experimental and theoretical methods. The following directions of research are included within the field of experimental methods: the mechanical characteristics (durability) of structure materials, main structures and their models.

Poland in the post-war period endeavored to create an experimental base, organizing durability laboratories with divisions for the analysis of deformation and stress. Research was undertaken by the laboratories of several divisions and institutes of polytechnical universities, the Polish Academy of Sciences, the Military Technical Academy and also--in individual cases--ministerial institutes (the Aviation Institute, the Institute of Architectural Technology, the Insitute of Precision Mechanics).

Research performed in the WAT in the field of analyzing stress and deformation dealt with the static and dynamic properties of new alloys and the elements of ship structures produced from them, the rheological properties of new types of light materials (laminates) intended for aircraft structures, the creep of valve steel, the determination, on the basis of elastooptical research and numerical calculations, of the state of the stress of the body and other elements of high compression, high power engines, the dynamics of engines' timing gears, methods for measuring the thrust of piston rings in automobiles and ships, elastooptical research on dynamic stresses,

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caused by concussion loads, oscillation and oscillation structures, the dislocation, deformation and stresses of bridges, etc.

The modern problem of analyzing stress and deformation is characterized by the search for new methods and ways to improve known ones. The intensive development of experimental methods based on the use of the phenomenon of polarity and the interference of light has been noted. Plane and spatial elastoptics, developed in the WAT, together with the reflection method and the use of oblique irradiation, can be counted among the more important methods. Laser beams and static and dynamic holography are now being used more frequently in the above mentioned methods.

Great importance is also ascribed to the method of tensimetric measurement, and especially--with the introduction of full automation with multi-point measurements--to the close and remote registration of data and the processing of the results with the aid of computers. One subject of research with the mentioned optical and tensimetric methods is elastic and inelastic solid state deformation. The phenomenon occurring in fluid bodies is being studied more often with the use of laser technology.

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Research in the field of elasticity and extraelasticity initiated in the WAT using elastooptical and holographic methods on heat stress, as well as research on stress waves in attenuating media, has a basic scientific and technical importance. In the field of direct technical application we must mention research tied to combustion engine structures and high compression boilers, as well as to the determination of the field of load pressures found in the base of a fortified object after the explosion of a nuclear or conventional charge.

Parallel to this, theoretical work has been carried out in calculating the state of stress in structures by using methods of the static and dynamic theory of elasticity.

In the 1950's new models of materials began to appear. These included heterogeneity, anisotropy, the rheology of polymers used in weaponry, plastic deformation, etc. At the same time the theory of thermoelasticity began to be developed and subsequently, in the 1960's--the theory of connected electro-magneto-thermo-mechanical fields. In recent years work has been conducted on Cosserat's micropolar theory elasticity and reticular systems. The problem of optimizing structures has also been noted. The method of finite elements, worked out in the WAT and introduced into practical engineering, has great practical significance for the numerical analysis of the state of stress and deformation.

THE STUDY OF MACHINE SYSTEMS AND ELEMENTS

The study of machine systems and elements belongs to a group of unusually diverse studies, but which mutually connect basic problems with those of direct usage--with problems of material engineering, with technological, exploitation and calculation problems. Therefore, research centers throughout the world are concentrating all their efforts in defined, specialized directions, determined mainly by the specifics of machines and instruments.

Research in this field carried out mainly in the WAT can be divided into the following basic groups:

- 1) work on the persistence of fatigue in elements and systems under conditions of modeled and exploitation loads;

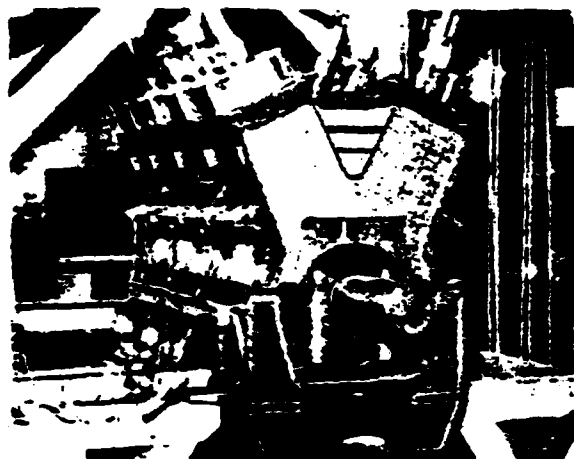
2) work on optimizing methods for calculating machine systems' fatigue by aid of computers;

3) cognitive work on the phenomena of fatigue in metals and the possibilities of the reconstruction of the history of the load of elements based on the microstructure of surface cracking and the possibilities of charting the course of cracking.

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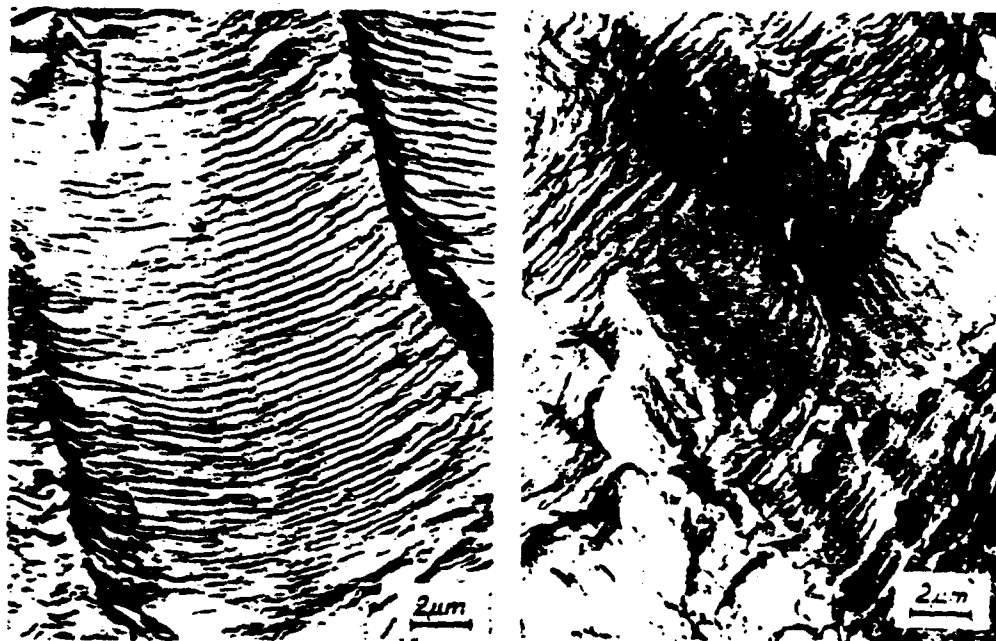
The results of some of this research has been applied in the designing of various equipment for the military (for example mobile rifle-ranges, the propulsion of rocket elements, bearings for rotating turrets) and for the national economy.

Summarizing this short retrospective of research in the field of mechanics performed in the Polish People's Army, we can claim that the achievements in basic and applied research have been impressive. The resonance of non-stationary waves in plastic bodies, the problem of the diffusion and effect of unidimensional and spatial plastic waves on objects, the diffusion of concussion and detonation waves and their effect on barriers found in the ground or in water, the theory of connected electro-magneto-thermo-mechanical fields, new concepts adequate for the realities of the theory of heat conduction, new concepts in quantum mechanics, basic work on the fatigue of metals, etc.--these are the accomplishments achieved by the cadres of the Polish People's Army, which have entered into world scientific literature and have played a concrete role in military technology.



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The elastooptical testing of models of high compression engines



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Fatigue cracking and lines in structural alloys; the photograph was obtained from a scanning microscope (a multiplication of around 5000 x)

9.5.

RESEARCH IN THE FIELD OF AERODYNAMICS, FLIGHT MECHANICS, AND THE AERO-ELASTICITY OF AIRCRAFT AND ROCKET DESIGNS

The rapid development of aircraft and rocket technology in the post-war period led to the intensive and broad development of research in the scientific disciplines connected to the theory of the movement of air ships (airplanes, helicopters and rockets). This includes aerodynamics and flight mechanics and in the case of considering air ships as deformed structures--also aero-elasticity.

Aerodynamics is one of the branches of the mechanics of liquids and gases, known as fluid mechanics. This is engaged in the study of the laws governing the flow of gases (especially air) and the identification of the forces which act on bodies moving in gaseous media. If the speed of the movement of gas or a body in gas is considerably less than that of the diffusion of sound in this medium, the gas can be considered as incompressible. In this case the law governing the movement of gases and liquids are the same. The aerodynamics of fluids considered as incompressible media are called low speed aerodynamics or classical aerodynamics.

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For speeds of movements, which approach that of sound in gas or which exceed this value the media's compressibility must be considered. We call the aerodynamics of compressible gas flows high speed aerodynamics or the dynamics of gases.

In application for the flight mechanics of air ships the solutions of problems of aerodynamics facilitate both the determination of the forces which act on ships flying in the earth's atmosphere and the establishment of the flight's course.

Flight mechanics is one of the branches of theoretical mechanics and is engaged in the study of the movement of air ships from take off until landing and in the identification of the basic aerotechnical parameters, stability and controllability throughout the entire range of flight speed and altitude. In the case of rockets flight mechanics are often called the ballistics of external projectiles and non- and guided missiles.

A series of questions concerning the flight mechanics of helicopters, airplanes and rockets can be examined from the basic fact that these ships are rigid structures, which cannot be deformed by the effects of aerodynamic forces. For fast airplanes and some types of rockets this basic tenet is not generally valid. When taking into consideration great aerodynamic force and limited structural rigidity, the issues of the aerodynamics and elasticity of such systems should be viewed together as complex, static and dynamic problems of the aero-elasticity and flight mechanics of air ships. 305

The study of the aero-elasticity characteristics of all types of air ships also facilitates the detection of critical conditions and vibrations which cause a loss of stability or which threaten the structural durability. Such phenomena consist of, for example, the "flutter" type of self-induced vibration of the carrying surface, the inversion of the effects of flight and the torsional divergence of the wings. These phenomena can occur with helicopters, airplanes and rockets, which travel at great, supersonic speeds.

In Poland research in the mentioned scientific disciplines was begun at the start of the 1950's in the Institute of Aeronautics, directed mainly to applied and industrial studies, in the Warsaw Polytechnical University and in the Institute for the Basic Problems of Technology of the Polish Academy of Science, based on fundamental research into 306

flow theory and physics.

The Military Technical Academy and the Airforce Technical Institute were later included in work in the field of the sciences connected with aeronautical technology.

The Warsaw Polytechnical University, the Military Technical Institute of Weaponry, the Aeronautical Institute, the Institute for Precision Mechanics and the Military Technical Academy are also occupied with the problems of rocket technology.

Between 1951 and 1954 a series of experimental and theoretical studies were performed by the Chair of Aerodynamics and the Construction of Airplanes of the WAT in order to determine the aerodynamic characteristics of small extension wings, oblique wings and wings with a delta configuration, with mechanization and without it. The aerodynamic characteristics of these wings were studied during low altitude flights, with consideration taken of the effect of Earth's gravity. The above work about the fundamental characteristics allowed a deeper understanding and acquaintance of the distinctive flight-technical characteristics of modern fast airplanes.

At the end of the 1950's and in the 1960's a series of theoretical works were undertaken in the WAT on the theme of non-stationary, supersonic flows, self-induced hull vibrations in a supersonic flow (hull flutter) and the flutter of deformed rockets. Work was also initiated on the theme of the problem of the continuous vibration of aero-elasticity systems. The solving of this problem facilitated the establishment of a way to preserve aeronautical structures deformed under the effects of external loads, which vary in time, taking into consideration the connection between deformation and the aerodynamic forces acting on the structure.

Experimental research was performed on the aerodynamic characteristics of airplane models with rotating wings and wings with varied geometry. The results obtained were applied in the analysis of the flight mechanics and dynamic stability of examined systems.

The Military Technical Academy also paid a great deal of attention to rocket technology. A series of studies was performed on the kinematics and dynamics of guided rockets.

In this period a series of experimental tests of the aerodynamic characteristics of rockets, shells and bombs of various shapes was performed in the WAT, WITU, ITWL and IMP. Design and modernization work was also carried out on new types of weaponry.

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Broad research was carried out in the field of the durability of the bonding of metal with the aid of adhesives and the bonding of laminated materials with duraluminum. The results of this research was used for the designing of technology for the repair of fuselage hulls with the application of adhesion technology.

In the WAT, moreover, a series of research studies was performed in the field of the industrial applications of aerodynamics for the needs of various branches of the national economy. Among others, the study of the optimizing of ventilation systems for radiochemical exhaust, digesters and assembly stations was performed for the "Polon" Nuclear Industry Association.

A series of aerodynamic tests of the H9 bus, produced by the Sanocka Bus Factory, was performed for the Polmo Motor Industry Association.

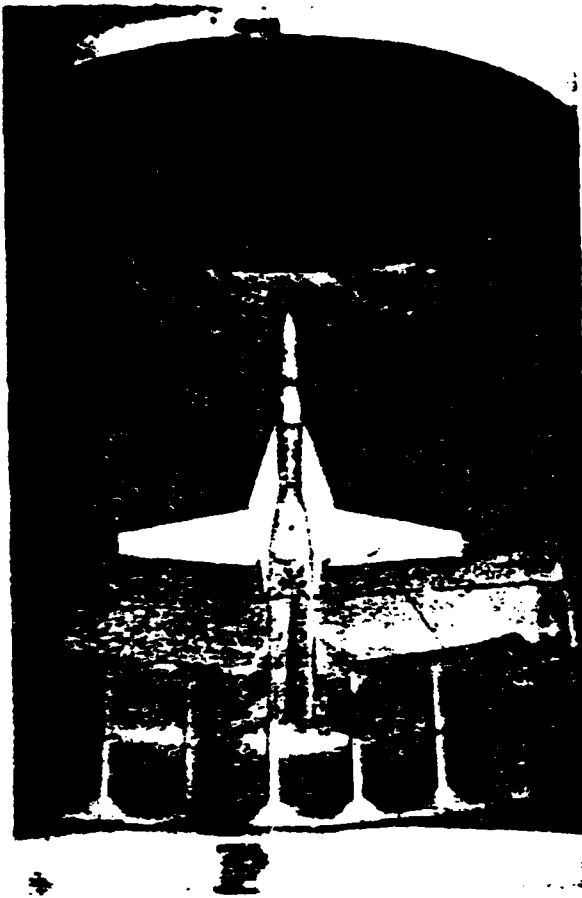
Between 1968 and 1972 a heavy-duty generation of control acoustical fields of great power was designed. A design projection and prototype of a high power dynamic siren were also made.

The constant growth of aviation and rocket technology requires the further improvement of the laboratory base and performance of perspective scientific work with aerodynamics, flight mechanics, aero-elasticity and structural-technological problems.

In connection with this a hypersound gun was designed and constructed in the WAT between 1970 and 1972. This was adapted to the firing of small mass projectiles at a speed of $1 \div 5$ km/s. This device allows research to be carried out in the field of the impact of projectiles with obstacles and facilitates the measurement of the parameters of gas during the projectile's hypersound flight. A series of basic studies were also performed in the WAT in the field of rocket technology.

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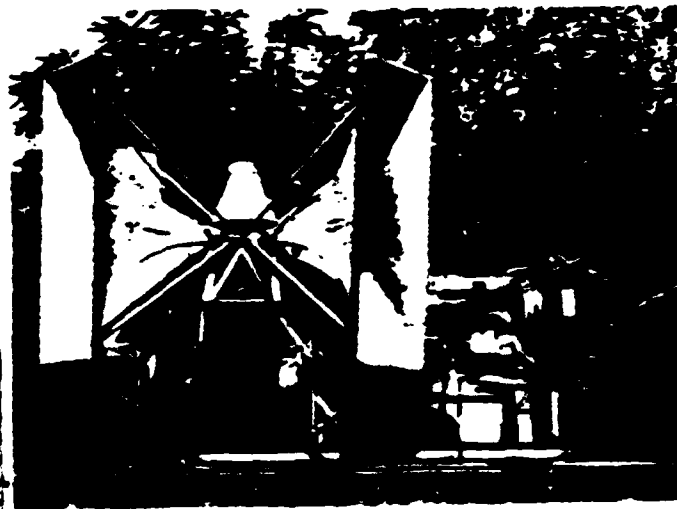
The testing of a model with varied geometry
in an aerodynamic tunnel of the WAT



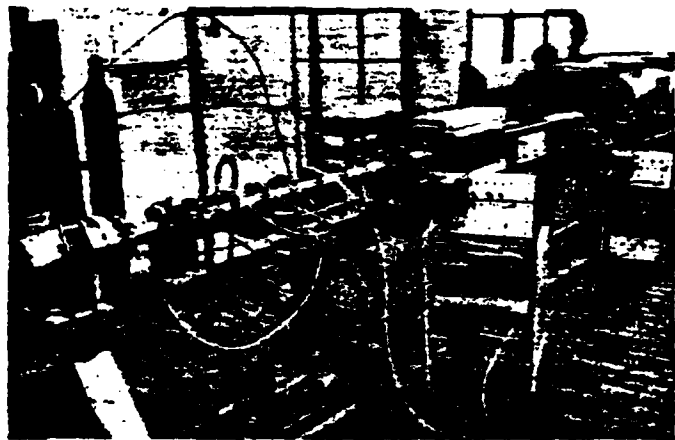
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The testing of a model of the Gp SFA bus in an
aerodynamic tunnel of the WAT



A high power dynamic siren designed
and produced in the WAT



A hypersound gun constructed
in the WAT

9.6 RESEARCH IN THE FIELD OF MECHANICAL VEHICLES AND WORK MACHINES

MECHANICAL VEHICLES

A mechanical vehicle is evaluated on the basis of its exploitation-technical properties, among which are included the following: traction, economy, steerability, stability of motion, ability to surmount difficult terrain, comfortable passenger ride, the dynamic loading of vehicle and carriage parts, durability and reliability. Those properties, which take on their highest values playing a great role on the battlefield, play a basic role in the evaluation of military vehicles. However, from the point of view of the vehicle's dynamics, they are contained in the mentioned exploitation-technical properties.

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The giving of the required technical values to mechanical vehicles is conditioned by the performance of research aimed at improving their systems and elements, and above all, their engines, drive mechanisms, carrying capacity, tires and others.

COMBUSTION ENGINES

The engines of battle and transport vehicles, as well as work machines used in the military, are most frequently four cylinder, piston combustion engines with automatic ignition. Engines with spark ignition are rarely used.

The high demands in relation to the engines used in military equipment are the impulse for developmental work in this field. The chief

technical requirements composed by the military for piston, combustion engines are: the replacement of carbureted engines by multifuel engines with automatic ignition, the achievement of power greater than 500 KM from a cubic meter of overall space, the obtaining of the engine's great reliability.

The possibility of combustion engines used in the military, which run on various fuels, facilitates the military's supplying with fuel and allows the use of captured fuel depots. Experience obtained in World War II shows that the transport of fuel makes up around 55 percent of all military transport. Presently, in all European armies, tanks, armored transports and a majority of transport vehicles are equipped with multifuel engines, adapted to the supply of various liquid fuels, such as : propulsion oil, aircraft fuel, gasoline.

The directions of developmental work on combustion engines in Poland are similar to those throughout the world. This work aims at increasing the the engine's economy and reducing its susceptibility to fuel types. It also aims at decreasing the toxicity of the combustion gases. Military scientific centers, including the Military Technical Academy and the Military Institute for Armored and Motor Vehicle Equipment, play a key role in developmental work undertaken in Poland, which concern the problem of engines with automatic ignition.

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Theoretical and design problems concerning multifuel engines were solved in the WAT in the 1960's. The problem of adapting domestic tank engines to the use of various fuels with gasoline was worked out in the WITPiS.

Presently, research is being carried out in the WAT on increasing the

efficiency parameters of an engine's operation, on the selection of combustion chambers and the creation of combustion control processes in newly designed engines with automatic ignition for medium load vehicles. This is connected with the general development of piston combustion engines in the direction of increasing the power per unit of displacement capacity and reducing the expenditure of the mass of construction material per unit of power. The solution of these problems is closely tied to the possibilities which correspond to the formation of the combustion processes.

Timely research, conceived on a broad scale, on the choice of fuel and lubricants and the increase of engine reliability and durability is being performed in the WAT. This work has importance not only for the military, but also for the national economy.

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Besides its advantages, piston combustion engines also have drawbacks. These include the negative course of the change of torque, the polluting of the atmosphere with harmful elements of combustion gases, noisy operation, vibration resulting from the slide-return motions of the pistons, heavy weight, high production and repair costs and complicated servicing.

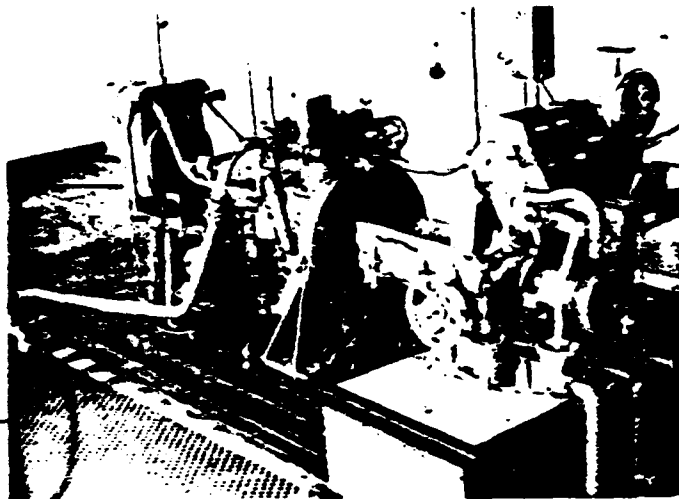
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The WAT is now studying engines with regard to the toxicity of their combustion gases and is trying to develop a method for neutralizing this. It has undertaken research on oil additives, which will reduce smoking and the number of toxic elements in combustion gases.

The problem of protecting the natural human environment is relatively new. It is tied to the increased poisoning of the atmosphere by the toxic elements of the combustion gases produced by engines. Included in this problem is the possibility of significantly reducing the

contents of toxic combustion gases by changing engine designs, by introducing new fuels and by using catalytic converters.

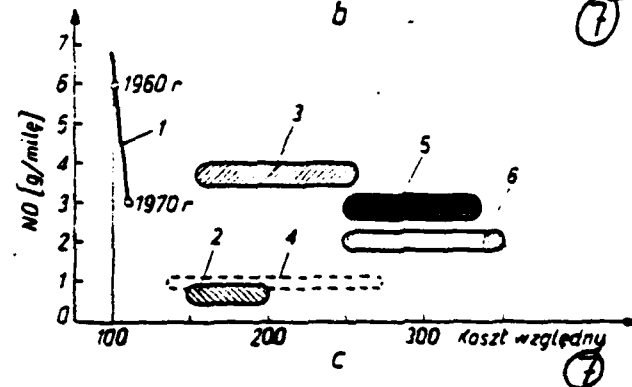
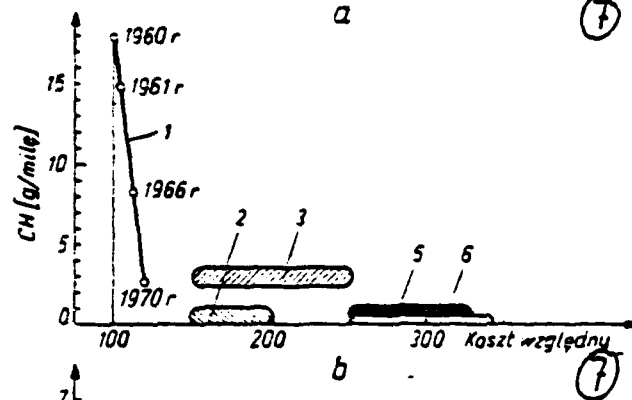
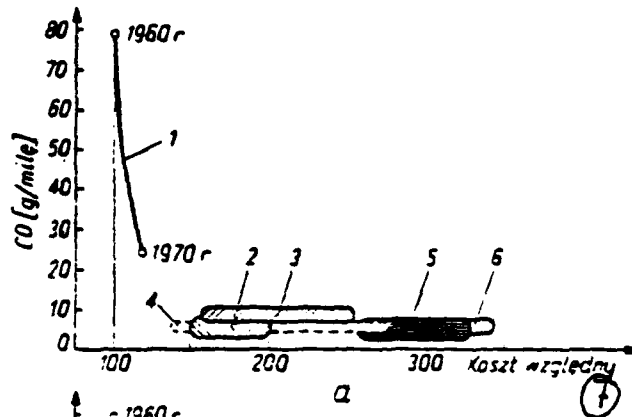
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A dynamometric station with the SB2 experimental engine



An analog system for the measurement of temperature in engine blocks



The unit emission of toxic elements by individual types of engines of corresponding power, taking into consideration their relative cost in relation to the cost of an engine with spark ignition designed in 1960. 1. an engine with spark ignition, 2. an engine with spark ignition, equipped with a combustion gas burner, 3. a compression ignition engine, 4. a steam machine, 5. a combustion turbine, 6. a Stirling engine, 7. relative cost

THE UNDERCARRIAGES OF MECHANIZED VEHICLES

One of the factors affecting the basic level of all the exploitation-technical properties of motor vehicles is the dynamic effect of roadbed inequalities on the vehicle. The vibration caused by this effect limits, above all, the vehicle's mobility.

With regard to this, the problem of the vibration of the vehicle's mass and connected with this the problem of its operation occupy a very important place in the theory of vehicle mobility. These deeply studied phenomena are conditioned by the research methods used.

The effect of a military vehicle's suspension on its mobility on various roadbeds, as well as on off-road surfaces, is especially great. The so-called adaptability quality of the vehicle's wheels to very unequal roadbeds and off-road surfaces depends both on the elastic properties of the frame together with the entire body and on the kinematic and elastic characteristics of the suspension, as well as the tires. The vehicle's stability and its steerability also depend to a large degree on these characteristics.

Research in the field of the vibration dynamics of motor vehicles began several decades ago. However, the analytical methods used in it were limited for a long time to the study of only linear variants of the vehicle's axles and tires, which did not solve the problem.

The first Polish test of the use of nonlinear mechanics for the study of vehicular vibration was carried out in the WAT between 1961 and 1963. Carrying out the analysis of a dynamic system with powerfully nonlinear elastic characteristics and elements which attenuate the

vibration, the possibility of the appearance of complex and negative forms of vibration arises in these systems, with the effects of determined constraints on this system. This takes into account, above all, the effect of the unevenness on the mobility of vehicles on roadbeds with bad surfaces or on off-road surfaces. The conditions, which limit the degree of the nonlinear quality of the characteristics have been determined. The possibility of improving the elastic qualities of the suspension has been established, based on the criteria of the minimal frequency of the vibration of the spring mass possible to achieve, as well as that of the smallest acceleration possible, sufficient for the suspension's energetic capacity and the limited dislocation of the wheels with regard to the roadbed with the smallest possible total sagittal deflection of the elastic elements.

The first theoretical work in Poland containing a development of the basic questions in the field of the nonlinear vibration of motor vehicles, treated as stochastic processes, appeared in the WAT starting in 1967. In these studies was developed by analytical methods the optimization of the basic suspension characteristics, with regard to the dry shield, which plays a negative role in the suspension. Among other things, a method was designed for determining the optimum universal characteristics of the shock absorbers, which provided a statistical method for the best attenuation of the vibration of an automobile travelling on various roadbeds at different speeds.

Parallel to the use of analytical methods, experimental research on suspensions was begun in the WAT on a wide scale. In 1966 and 1967 a method for laboratory and road study of vehicular vibration was worked out, used subsequently for the domestically produced Star vehicle, which included all the extant changes in the prototypes. The results of this research included instructions aimed at improving the design of these vehicles.

Between 1970 and 1972 a dynamic analysis of tractors with trailers, supply vehicles, which took into account changes in terrain, buses and heavy trucks for medium loads, was carried out, based on laboratory and road studies.

Both the WAT and WITPiS are engaged in designing methods for developing vehicular suspensions based on mathematical modelling, realized on digital and analog computers. In connection with this, measurements of roadbed unevenness, carried out on all types of roadbeds, were performed. The results of these measurements have provided the basis for the computer simulation of vehicular vibration on actual roadbeds.

Both the WAT and WITPiS are engaged in testing automobile tires. Included in this a broad assortment of tires produced both domestically and abroad. Some subjects of the tests are phenomena occurring in the zone of the tire's contact with the roadbed's surface, the modification of the distribution of the elementary forces under various operational conditions and the slipping of the tires' elements. The results of these tests have provided a basis for the improving of the design of tires produced in Poland.

In the WITPiS a theoretical analysis of the deformation of natural substrata and automobile tires in their joint interaction has been performed. This study also included a modelling of low pressure tires.

The question of tracked vehicle vibration has also been the subject of theoretical and experimental work performed in the WAT and WITPiS. This concerns the analysis of the vibration of tank bodies, the effects of that vibration on the accuracy of the tank's firing, the

effects of the tracks' motion on the angular vibration of the body, the modification of the initial stress in the tracks under the effects of the body's vibration and the regulation of the tank's stabilizer. In one of its tests, the WITPiS was occupied with the anguine motion of tracked vehicles.

Other work performed in the WITPiS included studying the issue of the vibration of tracked vehicles based on statistical dynamics. This led to the description of a method of measuring the unequalness of roadbeds, as well as the description of the theoretical basis of the vibration of tracked vehicles, caused by the chance formation of roadbed unequalness, in relation to linear dynamic systems. Also compared were systems for the equalization of the motion of tracked vehicles, treated as a spatial system of the mass connected by elastic elements and by elements which create inelastic supports. A method for detecting the load of the operating and drive systems of a tracked undercarriage of fast mechanical vehicles was also worked out.

In work dedicated to the study of the mechanisms of the drive systems of mechanical vehicles, performed in the WAT, was included a study of torsional clutches and their impact on the drive system. This study serves in the optimalization of the design parameters of the drive system. Studies on improving the clutches of heavy trucks have been made since 1970.

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Research has been carried out already for many years in the WAT and WITPiS on the application of hydromechanical transmissions in mechanical vehicles and machines.

Served both by analytical, graphic and experimental methods, WAT has performed a comparative analysis of differential mechanisms of

various designs from the point of view of the factors of the distribution of torque between the axle-shafts of the drive train. This research tied to the drive system of vehicles is still being continued. It expansion in the direction of the study of the dynamic loads in the drive system, treated as an elastic system, and in the direction of the introduction of hydromechanical transmissions is foreseen.

The expansion of research is also foreseen in the field of the general dynamics of motor vehicles, their steerability and stability, the effects of design parameters on them and the properties of tires and suspensions.

WORKING MACHINES

The development of modern military technology and the rate of the course of operation play a role in deciding the increase in the requirements making up mechanical engineering. In order to supply the military with machines characterized by great efficiency, maneuverability and universality, the Chair for Mechanical Engineering of the WAT and the Research Center for Engineering Equipment have performed a series of scientific-research work, aimed at the optimal adaptation of machines to various requirements and conditions of use.

Technical studies of engineering machinery and their operating processes have allowed the optimalization of their basic parameters and the designing of an entire series of new machinery, for example, excavators, bull dozers, cranes, transport equipment and others. At the same time evaluations of the serviceability of heavy machinery in military-engineering processes have been performed. The basic work

of the WAT in the field of ground formation has shown the effect of the speed of excavation on its concomitant support and the efficiency of engineering machinery, as well as leading to the design of new methods of ground formation under various climatic conditions.

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In order to improve the cooperation of the undercarriage with the ground, studies have been made on the attachability of wheeled and tracked machines. The results obtained have established the economic range of the machinery's usage in engineering.

Modern machinery design requires the introduction of new drive systems, based on hydraulic elements and units. Developmental research, performed for many years in the WAT, in the field of hydraulic drive, has led to the start of production of domestic clutches and hydrokinetic transmissions, as well as a series of machinery with hydrostatic drive. This type of machinery is characterized by its great efficiency, mobility and durability.

Research in mechanical engineering has shown that one of the perspective directions of development is the introduction of automated control systems. This was the signal for the study of remote controlled machinery and automated working processes. The results obtained promise with great probability that there will be essential changes in the future of mechanical engineering.

Already performed in the WAT, and presently being continued are studies on the durability and reliability of engineering machinery and their units. The need to introduce into the military fast operating engineering machinery with a power from 200 to 300 KM has led to the blossoming of the research base of the WAT, which allows the study of drive units, elements and systems in order to optimize basic

parameters and to evaluate the durability and reliability of operation.

The choice of control systems and the variability of dynamic loads play a very large role in the evaluation of machinery designs. This requires the performance of a series of studies in the field of machinery identification. The dynamic loads of machinery in the working cycle and the effects of the control system on the size and variability of these loads have been established.

The theme of scientific work presented is being continued and will be expanded with the beginning of complex research on the adaptability of machinery for operation under various climatic conditions. A chamber, allowing the study of machinery at temperatures to -60°C , has been built at the WAT for the study of working machinery and their units at low temperatures.

9.7.

RESEARCH IN THE FIELD OF MILITARY ENGINEERING AND GEODESY

Military engineering and geodesy comprise the area of transfer field tectonics on the basis of the broadly conceived problems of national defense. Consequently, the scientific achievements in the field of the designing of diverse engineering structures and their geodesic service are utilized and developed, as well as the technology and organization of work connected with their performance under the specific and frequently very demanding conditions of the battlefield and the preparation of the national infrastructure for defensive purposes.

Military engineering encompasses, consequently, on one hand, the building of bridges, roads, airports, barracks necessary for the military and its operations directly connected to the corresponding activities of land tectonics, and on the other hand--such activities as the construction of fortifications, mines and barriers, technical camouflage--making up the detailed operations not met in general field tectonics.

Scientific research in the field of military engineering, performed in Poland chiefly by the WAT and the Research Center for Engineering Equipment in cooperation with civilian scientific institutions, encompasses a wide range of issues, which can be separated in the following manner:

- the optimal construction design of diverse engineering objects and the conditions possessed in objects subjected to short term dynamic loads of great intensity;
- the optimization of the technical-organizational processes connected with the construction of these objects; the optimization of the organizational structures of the constructors;
- the methods and techniques for the in situ modelling studies of

structures subjected to complex loads;
--mining techniques;
--the engineering of construction material;
--spatial planning with regard to defensive aspects.

Military geodesy, developed in the WAT in cooperation with the Institute for Geodesy and Cartography, the State Photogrametric Bureau and the PZO, concentrates its scientific activities on the problems of automating geodesic measurements and the remote study of geographical environments. 317

THE ENGINEERING OF CONSTRUCTION MATERIALS

An important turning point has been reached in the last thirty years in the field of construction materials. A new discipline of science, "materials engineering," has appeared, which is introducing into technology new materials with interesting characteristics and properties. These materials are constructed as a rule in an artificial manner, as a result of the synthesis of organic compounds. They form a huge family of multi-molecular materials. Polyvinyl chloride, polymethyl metacrylate, polystyrene, polyurethane, epoxides, urea substances, phenols, phenol resorcins, phenol formaldehydes and as parts of synthetic compounds, which through modification processes, through different transformations, create the basis for the composition of new materials.

The significance of these materials and their perspective development have been demonstrated in plastoconcrete and new technology for the hardening of soils, and consequently, these directions, have been especially developed in the work of military scientists, chiefly in the WAT. The development of synthetic resins has led to a growth of

interest in the science, which utilizes their characteristics for the needs of engineering.

New materials based on synthetic resins, such as plastoconcrete, have appeared. Plastoconcrete is concrete in which the cement has been replaced by synthetic bonding agents. (We say that polimerconcrete is "cement concrete" improved by synthetic admixtures of predominately organic derivation).

Voluminous and long term research performed in the WAT has led to the designing of new technology for the polymerization of plastoconcrete under field conditions at temperatures between -15 to $+35^{\circ}$, and consequently, under conditions which rule in our climatic zone for the entire year.

Research based on numerous concrete examples has led to the documentation of the basic idea of materials engineering: the possibility of creating in a technological process the characteristics of materials, required by the designer-builder.

For example, the surface stabilization of soil, whose method was worked out in the WAT, points to the superiority of the technology of the use of synthetic materials even in this field. Earlier methods of road construction demanded a soil of corresponding type and with appropriate granulation. Organic soils were removed from the bottom of the projected roadbed. Inherent in this were huge costs and prolonged construction times. The processes of hardening and maturing of the surface took almost 4 weeks. Even in the national economy such a long period would be arduous. Methods worked out for the utilization of triturated synthetic phenol-resorcin-formaldehyde resins can, however, stabilize every kind of soil

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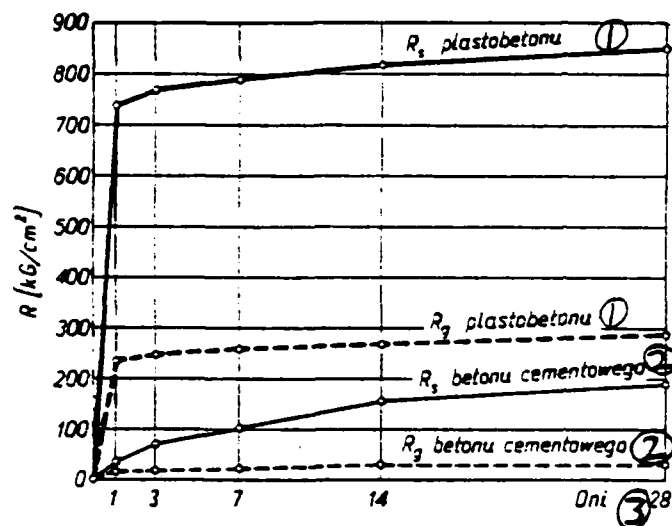
without the need of its replacement. These methods also allow the stable use of roadbed sections for tens of years.

The materials, like every other, have their drawbacks: little resistance to high temperatures, affinity to spontaneous aging and less usefull rheological characteristics. The elimination of these and similar drawbacks of synthetic substances, by the introduction of the appropriate compounds into the chemical structure, by their appropriate modification, by new hardening technologies, is just a question of time.

Newly developed substances will be able in the future to simplify growing tasks and social needs. The study of new construction materials from the point of view of their application in military engineering remains, consequently, a real task of military scientists.

A comparison of the parameters of the durability of type 200 cement concrete and polyester plastocrete

1. plastocrete, 2. cement concrete, 3. bottoms



9.8 RESEARCH IN THE FIELD OF WEAPONS TECHNOLOGY

Technology is the factor which conditions the realization of design ideas. Simply put, technology limits the development of designs, when as a rule the modern foundations of designers in the field of materials and technology are not fully met. Taken generally, technology throughout the world has not kept up with the development of design ideas. In this situation the development of new technological directions has both a special economic and technical significance. Therefore, in recent years in all the highly developed countries, the development of technology, including weapons technology, has been surrounded with special attention.

However, the huge role which technology plays in overall costs must be greatly stressed. Consequently, modern technology strives for the newest materials and designs, but it is also necessary to secure, with the complete modernization of weaponry, the lowest possible cost.

The technological issues of weapons production have, especially in recent years, received their corresponding rank. This was caused by the fact that in the initial period industry, operating chiefly on licensed documentation, directed its attention to meeting the demands of this documentation, which required great efforts in order to solve the many technical problems.

On in recent years has the technological problem of weapons production moved to the fore of issues that could be solved by industry and the corresponding scientific-research agencies. Included in this are military agencies: the Military Technical Academy and the many scientific-research military institutes.

The main directions of research in the field of technology aim at eliminating processing by cutting to a maximum degree possible and applying of other materials with durability characteristics no worse than those used earlier, which allow simple, cheap and rapid processing.

Technological work performed in military scientific agencies is not limited only to the production of weaponry. In the 1960's the technology was worked out for the removal of accretions by a firing method in rotory industrial furnaces. The application of this method ensured the national economy millions in savings, which resulted from the increase in the furnaces' utilization time, which was subsequently tied to an increase in production.

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Presently, the production technology for thin seam welded pipes is being developed in the WAT. An essential characteristic of this method is the double linear seam weld, which gives the pipes great durability and air tightness at a pressure of 40 atm. Together with this method was designed and produced a production line, on which around 70 km of pipe is made. These pipes made from zinc-coated tin bands are two times lighter than imported pipe, and are significantly cheaper. The production of these pipes was begun with the cooperation of military specialists.

* * * *

The present discussion does not exhaust all the basic problems studied in the last thirty years.

The effect of the scientific activity, whose development and achievements were presented in this chapter, in the form of new theories, scientific designs and techniques, modern production technology and even new devices and materials, has influenced in an

essential manner the progress of science and military technology, as well as the the elevation and strengthening of the defensive abilities of the Polish Army. This has played also both a theoretical and material role in the national economy.

The developmental probabilities in the present period are characterized by the constant increase in the share of the scientific-technical factor in economic and social progress. The attainment of progress in every field is, therefore, conditioned by the development of science and technology in that field. This creates the objective need for the further intensive development of science and military technology, and especially for basic research in order to secure the ability of national defense, closely tied, simultaneously, with the development of the science, technology and economy of the entire country.

10. DEVELOPMENTAL TRENDS IN MILITARY TECHNOLOGY

The process of providing the military with the most modern weapons and technical equipment is a living, continuous process, closely tied to the nation's present doctrine of defense, economic potential, technical and technological level and general world tendencies of the development of military equipment. Principles of the performance of battlefield activities, which change with the course of time, exert a great influence on the designing of new types of weapons and military equipment. On the other hand, there also exists a reverse relation, which depends on the fact that new types of weapons cause changes in the development of battlefield strategy. World tendencies in the field of the development of defensive technology and the need for our army to consider them make up an essential part of the defensive system of all the states of the Warsaw Pact. They determine the character and directions of the improvements and modernizations of the weaponry and technical equipment of our military.

Speaking about the tendencies of the further development of military equipment, we should keep in mind, above all, the development of the technical means of detection and radioelectronic counteractivities, anti-aircraft defenses, the technical means for communications, command and directing of the military forces, fire power and the possibility of rapid maneuver, the means for protecting our forces against weapons of mass destruction, as well as the development of engineering equipment and the technical means for the securing of battlefield activities.

Below are sketched the developmental trends of the most important branches of military technology.

In the field of radar and detection devices we must point to the designing of new types of radar stations for detection and aiming, the so-called three dimensional stations with computer systems for processing radar data. This is a qualitative jump in data output and efficiency, which allows one station to significantly increase the number of objects it can simultaneously track. The number number of these objects can reach tens of air targets.

An offshoot of this developmental direction is the designing of special stations for the detection of low flying objects. These stations permit the lowering of the detection ceiling of enemy aircraft to just a few tens of meters above the ground, protecting the gap in radar systems, which until recently existed between detection and guidance systems.

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Finally, the other direction is the improvement of radar stations for the detection of surface objects and the observation of the forward section of the battlefield, intended for operational forces. Included here are also radar sights for rifles. This equipment creates the conditions for the effective operation of our forces under conditions of limited visibility, day or night.

The very broad application of electronic weaponry, introduced into the military both in the form of detection and anti-detection devices, as well as in the form of systems which increase the resistance of our own stations to all types of counter-electronic measures, has been observed.

In the field of the construction and the technology of the production of detection equipment we have seen the expressed tendency to move toward a technology of scaled and hybrid systems, as well as the broad

application semiconductor generating elements. This has led to a significant decrease in equipment's dimensions and an increase in its reliability.

Great progress has been observed in the field of detection with the improvement of aeronautical and space detection equipment, by using the newest developments in the fields of conventional aviation photography, optical electronics, lasers and television. A characteristic trait of many modern detection devices is the transmission of information concerning the potential of attack ground forces within a reasonable amount of time, thus allowing the localization of targets.

Detection equipment operates on the basis of signals transmitted by sensitive infrared elements, highly sensitive cameras operating with a low level of illumination, radar antennae and other devices. Telemetric systems for the immediate transmission of information to command centers and stations and detection data processing and accumulation centers cooperate with the detection equipment.

Besides complex detection systems, which transmit information at great distances, there are simpler devices for the observation and identification of targets used by the crews of battlefield vehicles, anti-submarine forces, tank and armored vehicle crews. A key role is played in this respect by passive nocturnal vision equipment, operating with infrared light. Greater consideration is also being given to the development and improvement of precision laser devices and the detection and tracking radar stations which work with them. These stations are included in the components of integrated systems for the guiding of the fire of deck and surface weapons.

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The introduction of multibarreled automatic gun and cannon systems, their mounting on self-propelled chassis, together with radar-computer systems, which ensure the detection of targets and the guiding of fire, are being observed in the field of anti-aircraft defense. Instead of the hitherto used medium and large caliber anti-aircraft cannon, anti-aircraft guided missiles doubled with automatic guns and small caliber cannon, intended for fighting low flying targets, are being introduced into the military. Medium range missiles for fighting low altitude targets (up to the stratosphere) and small and medium range anti-aircraft missile systems are also being introduced.

Dynamic development has also been observed in the field of anti-armor, guided rocket projectiles. This tendency, together with the development of modern methods of warfare, seems to be intensifying. The further development of anti-armor guided projectiles, therefore, is moving rapidly in the direction of the automation of firing systems and the improvement of the other tactical-technical characteristics of this weaponry. The dimensions and weight of these projectiles are simultaneously being reduced, thanks to which these projectiles are suited to portable launchers. This means that light guided projectiles can be found in even small subunits and will be used in the various conditions of war. These projectiles are also being introduced into the weaponry of armor transports, which can effectively fight tanks.

Parallel to the development of anti-armor, guided projectiles, various types of anti-armor grenades with accumulation action projectiles, which are used by the individual soldier, are being developed in many countries. Great attention is being given to the massive use of these grenades on the battlefield.

The further possibilities of the development and improvement of armored weapons, as one of the basic elements of land forces, is being sketched out. The medium tank, as the basic type of tank of the modern army, is undergoing systematic modernization. With the application of nocturnal vision observation and sighting equipment the tanks are being adapted to nighttime action even under conditions of limited visibility. The accuracy of tank fire is being increased by the use of cannon stabilizers, which allow accurate firing while moving, as well as by modern range-finders, mainly lasers, which allow the accurate and rapid determination of the target's distance. Tanks are being adapted for the surmounting of deep water barriers, chiefly by the method of forcing the barrier to its bottom.

The design of light, armored vehicles, which possess powerful armaments and a great maneuverability, intended for collaboration with tanks on the battlefield and for reconnoitering, is undergoing intensive development. Simultaneously, the aspiration to decrease this type of vehicle's weight by using light alloys, ceramic materials or plastics in its armor and to improve its ability to be parachuted, as well as securing its ability to maneuver in water, can be observed. A thin coating of plastic is being placed over the armor of these vehicles in order to protect them from the affects of radioactive radiation and napalm.

In the modern airforce the expressed tendency toward the broad introduction of multipurpose airplanes and helicopters is being observed. Multipurpose, battle air ships are being developed mainly in the form of airplanes with reduced wing geometry, adapted for flight and attack at various altitudes and at various speeds. Multipurpose medium load helicopters capable of carrying out missions under various atmospheric and terrain conditions and adapted to fight land, sea and submarine targets, are also being developed.

Also developed and slowly introduced into serial production are aircraft capable of vertical take off and landing. This is tied to the need to limit the growth of the length of runways at airports, required for the taking off and landing of aircraft with relatively great landing speeds, and consequently, also with relatively long take offs and landings. The need to develop vertical taking off and landing aircraft is tied, moreover, to that of ensuring multipurpose battle aircraft of good flight properties both at slow speeds--especially during the take off and landing phases, and during low altitude combat missions--and during combat missions at great speeds and altitudes. The development of vertical take off and landing aircraft leads to the designing of new aircraft propulsion systems and radical modifications in the take off and landing procedures. These are connected to the significant progress made in the field of aerodynamics research and aircraft design.

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Great attention is also being paid to light aircraft with abridged take off and landing, adapted to the fire support of land forces on the front lines and for fighting individual targets. These aircraft are armed with different variants of external weapons, elevated on the catch under the body and wings, mostly nonguided rockets or anti-armor guided rocket projectiles.

The development of naval forces is aimed at the supply of rockets to all classes of fighting ships and some specially designated vessels. At the same time the expressed desire to build universal and multipurpose fighting ships, with the installation of powerful weapons, intended for the fighting of various types of targets, has been observed. Submarine designs have been developed and improved in order to more effectively fight enemy submarines. In closed waters is found the broader application of torpedo boats and rocket cruisers--small ships, which are marked, however, by great fire power, maneuverability and speed. Rocket destroyers have also undergone

further development and universalization, as one of the perspective types of surface fighting vessels.

In field of naval propulsion heavy-duty and small dimensioned propulsion engines and gas turbines are being used more widely. The utilization chiefly of atomic power systems, as a prospective type of propulsion, is anticipated in fighting ships, mainly rocket destroyers and submarines. 328

The further development of landing craft--both helicopter landing ships as well as medium and small units--is foreseen. It must be admitted that the further, perspective development of these crafts is aimed at the broad use of hovercrafts.

The very broad introduction of automated ship engines, the construction and use of automated ship steering systems, as well as deck weaponry and energetics systems make up a very interesting and perspective phenomenon.

The development of modern communications, command and direction systems, as well as the broad introduction of new computer systems also deserves attention. An essential phenomenon in this respect is the significant, constantly growing increase in the range of military radar and the significant increase in the number of their working waves.

Another aspect of the intensive development of communications is the automated transmission of coded and uncoded information, as well as the mastering of modern techniques of rapid and errorless information transmission via wire and wireless systems.

Much greater efficiency has been obtained in the field of the miniaturization of communications elements. Since the period right after World War II when a military radar station was transported in 3 motor vehicles, much has changed. Modern radar stations are contained in one motor vehicle, albeit with considerably improved technical-utilization parameters. Progress in the field of the miniaturization of communications devices is being constantly intensified.

Great significance is being attached to the improvement of the organization of military command and the improvement of the command process. Modern technical material for the performance of military activities has become unusually complicated systems of various devices, whose utilization on the battlefield requires the coordination of command with a speed and precision not attainable today for the human reflex and senses. The main factor of a modern command system, which corresponds to real and future conditions of warfare, is the complex automation of military command and weaponry, in which modern management means, broadcasting, data processing and the predicting of optimum decisions in determined battle situations will play a basic role. Other, organizational-technical staff equipment will also find application in systems for the complex automation of command. Developmental activity in this direction in recent years has enjoyed a significant intensification.

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In recent years the world has witnessed the considerable development of engineering equipment, which ensures the activity of operational forces, and above all, transit-bridge equipment, earthworking machinery and mining and mine disarming devices. The aspiration to make pontoon bridge systems self-propelled, to introduce block-design systems, which allow the construction of river pontoon bridges, and the use of concurrent bridges installed on tank chassis and armored vehicles has also been noted.

In the field of earthworking machinery a basic developmental trend is the desire to build multifunctional machines, although the abandonment of specialized, one function devices, intended for trenching, excavation and other earthworking projects, is not planned.

Independent of the above directions of the development of engineering equipment is the further modernization of sapper tanks.

There will appear in future years on the horizon of military technology weapons and devices, which today have barely been sketched by designers or futurologists. For example, it is considered possible that lasers will be widely used on the battlefield as weapons of direct destruction or ancillary devices, which will increase the effectiveness of different types of weapons. This also takes into account the affects of laser radiation on materials, the energetic possibilities of lasers and the long-range transmission of radiated energy. The possibilities of the use of laser technology for plasma heating in order to initiate a controlled thermonuclear reaction are also being studied. The military utilization of a nuclear synthesis, initiated by a laser source would lead to the development of the so-called neutron bomb--whose essential trait is the lack of radioactive contamination, which severely hinders the actions of domestic forces in an area where nuclear weapons have been used.

Great progress in the development of chemical weapons has been observed in the capitalist countries in the last decade. From this arises the need to carry out intensive work in order to protect the military and the civilian population against chemical weapons, with special regard to the protection of the respiratory tract and skin.

At the same time intensive and permanent conversations have been going on between the representatives of the great powers, military blocks and in international conferences, having as their goal the reduction of armaments and the limitation and braking of work on offensive weapons, leading to the impression that the societies of many countries are worried by such weaponry.

* * *

The developing technical revolution and the explosion of inventions, discoveries and new designs in the field of the construction and technology of machinery inseparably connected to it have caused the fact that presently the developmental possibilities of military technology are ultimately unlimited. For the first time in the history of the development of military technology the technological and design possibilities of military equipment are to some extent outdistancing the needs of the battlefield. We are the generation, which dares not await the appearance of the technological possibilities of the realization of the most daring developmental concept. Formerly, as perhaps the example of the airplane proves, the idea of constructing a certain military machine had to wait not only many decades, but even centuries for its technical realization. This relation has now been essentially reversed: the key problem is not the real possibilities of the technical realization of a project, but the priority of the choice of a developmental direction, dictated by actual and planned operational concepts and the fundamentals of the doctrine of the use of a given type of weapon or technical equipment.

It must be admitted that on the basis of such a sketched perspective of the general development of technology, including military

technology, we can point to the following group of systems, which will be given priority in the field of expenditure and resources for their development and introduction. To the leading group must be included all types of vehicles, then construction materials, especially for the building of technical machinery; in subsequent periods it will be necessary to point to the development of the design forms of equipment, to the development and improvement of propulsion, systems of automation and command, as well as surface devices and equipment. At the same time the development of military technology will obtain a much more complex, systematic character. 331

On the basis of the modern developmental trends of military technology, special expression will be given to the role of the human being, as the analytical, selective cell--as the one factor predestined for the making of decisions. Surrounding us today is a wealth of technology, which presents us with many developmental paths from which to choose, some to reject and others to accept and accomplish. Modern man must be prepared both to utilize the huge technical possibilities and to decide on the directions and developmental paths of military technology.

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THE MILITARY TECHNOLOGY OF THE POLISH PEOPLE'S ARMY 30
YEARS OF DEVELOPMENT(U) FOREIGN TECHNOLOGY DIV
WRIGHT-PATTERSON AFB OH H LATOS 20 DEC 83
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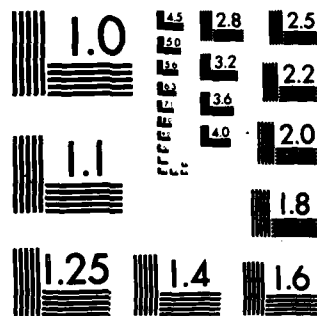
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MICROCOPY RESOLUTION TEST CHART
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SUPPLEMENTARY

INFORMATION

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In recent years an unusually rapid development of technical sciences has been noted. The science, however, which leads in this development, whose tempo of change is the greatest--is electronics. One only has to remember that we passed through only one generation from the birth of electrical lamps to transistors, and presently we are entering into integrated systems, which are completely changing the face of electronics.

The development of other scientific disciplines are also conditioned by electronic progress, and especially new, automated measuring devices, an entire gamut of information and mechanical equipment and in general the entire infrastructure of contemporary technology.

The role of electronics in the development of modern military technology is unusually essential. Examples of this discipline, which exist only, or chiefly, in military applications include:
--radar--using the propagation of electromagnetic waves for determining the position of objects;
--telecommunications--which form a military system of communications networks and means with specifications and parameters higher than in civilian applications.

The existence and development of this two disciplines would not have been possible without basic research, which was performed in divisions subordinated to the Ministry of National Defense. The following must be included among the important disciplines:
--quantum electronics, whose appearance and development in our country is closely connected to the army, and especially to the Military Technical Academy (WAT); the first lasers were developed here; WAT won the deserved function as the coordinator of this discipline on the national scale;

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